Joe R. Davis

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Argonne National Laboratory

OPERATING INSTRUCTIONS FOR EBR-I, MARK III

I have received my copy of the Operating Instructions for EBR-I, Mark III Facility. I have read the Operating Instructions and understand how they apply to the operation of the reactor.

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Copy Two. To be retained by the Reactor Operation's Supervisor.

Book No. ______

ARGONNE NATIONAL LABORATORY
P. O. Box 299
Lemont, Illinois

OPERATING INSTRUCTIONS FOR EBR-I, MARK III

Idaho Division

April, 1958

Operated by The University of Chicago
under
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OPERATING INSTRUCTIONS FOR EBR-I, MARK III

I. INTRODUCTION

This Operation Manual is intended to provide general descriptive information and operating instructions for the EBR-I, Mark III, reactor and its associated equipment.

The Chief Operator shall have complete charge of the facility and shall see that operation conforms with instructions as outlined in this report.

In no case shall any exceptions be made without the approval of either the Division Director or Associate Division Director.

Only authorized personnel will be allowed at the controls of this reactor. A list of such personnel will be posted and kept current.

Any operating procedure which differs greatly from standard or experiments which might lessen the safety of the reactor shall be approved by the Laboratory's Reactor Safety Review Committee before performance. Either the Director or Associate Director of this Division shall decide when such operation or experiments come under this category.

During routine operation, the operating crew shall consist of at least three qualified people. There shall normally be at least two of this crew in the control room at all times. At no time shall this room be left unattended by authorized personnel during operation or before the reactor is under satisfactory shutdown conditions.

All keys for special locks in the reactor system shall be in the possession of the Chief Operator. At the end of each shift they shall be transferred to the Chief Operator in charge of the next shift or locked in the special cabinet provided.

II. DESCRIPTION OF REACTOR COMPONENTS

A. Reactor Tank Assembly

The reactor vessel, or tank, is double walled, as is the piping which leads from the reactor vessel through the reactor shield. The part of the reactor vessel surrounding the reactor core has an inside diameter of 15.87 inches and a length of 28 inches. Above this small diameter part, the reactor vessel increases in diameter and is filled with shielding material, mostly steel. The whole reactor vessel rests on the shoulder formed where the diameter changes; thus the reactor core itself projects below the point of support as a smooth cylinder.

The stainless steel plate on which the reactor vessel stands is slotted to provide cooling air, which first flows over the outside cover of the reactor tank and then through the slots, thus cooling the reactor support. It then is drawn through the outer blanket.

The small diameter part of the reactor tank consists of a stainless steel vessel of 5/16-inch wall thickness, made by deep drawing. It is surrounded by a second tank made of Inconel, 1/16-inch thick. The second tank fits snugly on ribs which have been formed in the Inconel. The upper portion of the reactor vessel also is double walled. The double-walled construction serves a number of purposes. The gas space between the two walls provides some thermal insulation; it gives a method for testing for integrity of the inner vessel at any time; and, finally, in the event that the inner vessel should develop a leak, the outer vessel would prevent any serious consequences.

B. Outer Blanket and Control System

The outer blanket consists of 84 keystone-shaped bricks of natural uranium, each weighing about 100 pounds. These bricks are jacketed in stainless steel of 0.020-inch thickness. The bricks fit together in a stable array because each is provided with a recess on top into which fit projections on the brick above it. Air-cooling of the bricks is obtained by drawing air through five holes which are fitted with sleeves in close contact with the uranium. In order to increase the area for heat transfer, each sleeve carries fins on its inside. Each brick also provides a passage for a control rod, and air is drawn through this passage.

There are 12 control rods, each 2 inches in diameter, made of natural uranium jacketed in stainless steel. These move vertically in the outer blanket bricks. Eight of these control rods normally are used as safety rods. Their time of travel out of the blanket is short: 0.085 second to initiate motion, and 0.38 second to reach 16 inches. The remaining four normally are used for the running controls and can be positioned with considerable accuracy. Their maximum speed is 0.64 inch per second. Figure 14 shows control rod and safety rod positions. The whole outer blanket is mounted on an elevator which is hydraulically driven. The elevator can be driven upward at a maximum speed of 0.32 inch per second from 80 inches to 30 inches and at 0.095 inch per second from 30 inches to $4\frac{1}{2}$ inches. The last $4\frac{1}{2}$ inches of travel are mechanically controlled, permitting location of the outer blanket around the reactor core with a precision of 0.001 inch. Maximum speed is 0.005 inch per second. For shutdown, the outer blanket, the shield plug on which it rests, and the elevator can be dropped quickly: 0.1 second to initiate motion and 0.46 second for 12 inches of travel. The handling of the outer blanket for replacement of bricks is done by lowering the elevator and lifting the outer blanket from the shield plug with a handling dolly and transporting it into a neighboring shielded room. There it is disassembled with a remotely operated manipulator. In addition to the rods, a part of the outer blanket, in the form of a cylindrical block, is arranged so that it can be driven out of the bottom of the outer blanket with pneumatic force. Figure 15 gives reactivity versus period for EBR. Figure 16 is a calibration curve for jack position on EBR-I, Mark III. Figure 17 is the calibration curve for four control rods moved together.

Control and safety rod speeds and rate of reactivity insertion of Mark II and Mark III are similar. The following table is based on measured speeds of the mechanisms and reactivity calibrations of the safety devices. Reactivities were obtained from the delayed neutron data of LA-2118, adjusted to account for U^{238} fission using $\beta_i \times 10^3$ = 0.234, 1.377, 1.257, 2.760, 0.974, 0.228.

Reactivity Insertion

	Speed, Inches per Second	Reactivity Change, $\Delta k/k$ per Second
Control Rods - 4 (withdrawal)	0.64	1.4×10^{-5} (per rod)
Safety Rods - 8	0.64	1.4×10^{-5} (per rod)
Safety Block - 1	5	4.9×10^{-4} (avg)
Cup (80" to 30") - 1	0.32	-
Cup (30" to $4\frac{1}{4}$") - 1	0.095	6.7×10^{-4} (max. est.)
Cup ($4\frac{1}{4}$" to 0") - 1	0.005	1.2×10^{-5} (max.)

Scram Speeds

	Time to Initiate Motion, Seconds	Total Time for Indicated Travel, Seconds	Reactivity Change, Per Cent $\Delta k/k$
Control Rods - 4		No Scram Provision	
Safety Rods - 8	0.085	0.38 to 16"	0.20
Safety Block - 1	0.15	0.35 to 6"	0.06
		0.275 to $4\frac{1}{4}$"	0.80
Cup - 1	0.1	0.46 to 12"	4.00
		Total Travel	8.00

C. Inner Tank Assembly

The inner seven hexagons are fuel assemblies, and the outer ring of twelve hexagons are blanket assemblies. Located at the core center line on each of the six flats on the outer periphery of the assemblies is a double wedge-type clamping device used to force the outer assemblies against the center one. The outer, axially moving wedge is made of aluminum bronze, and the inner radially moving wedge is of stainless steel. These wedges are operated individually by means of reach rods by screw and nut actuators on the top plate of the inner tank assembly. There are twelve downcomer holes through which the inlet NaK flows under parallel flow conditions.

The structure, known as the Inner Tank Assembly, is shown in the cutaway drawings, Figure 2. This drawing also shows the inner and outer reactor tank, the outer blanket, control and safety rods, inlet and outlet piping, and some of the lower shielding. The structure inside of the reactor tank is made up of laminations of stainless steel rings which have cylindrical outside surfaces and inner surfaces forming a hexagonal pattern to fit the outline of the hexagonal blanket assembly. These stainless steel rings are aligned and held together with tie rods. At the bottom of this structure is a fuel assembly supporting plate, known as the tube sheet, which has circular holes to receive, support, and locate the nozzles of the rod assemblies. To enable the outer assemblies to be clamped against the center assembly, the clearance between the nozzle and the hole in the tube sheet is small for the center assembly and progressively larger toward the outer part of the plate. The lowest large diameter plate, called the mounting plate, supports the entire inner tank structure on a ledge in the reactor tank. In the region just above the mounting plate and outside the rod assemblies is the inlet plenum chamber. In this plenum chamber is an outer ring baffle which forms an annular flow distributing chamber between the tank wall and the baffle. Between the baffles are located four 3-way inlet valves with spool-type discs. Their purpose is to permit changing of core and blanket flow to either parallel or series. These valves may be operated individually from the top plate by means of extension shafts and nut and screw actuators.

Immediately above the inlet plenum chamber is the seal plate. On its outer periphery are two Inconel seal rings, similar to piston rings, which seal the area between the inlet and outlet plenum chambers. These rings may be expanded or contracted by a screw and toggle mechanism buried in the seal plate and operated from the reactor top. The aluminum bronze bushings for the inlet valve shafts are located in this plate. On the inner edge of this plate are the seal plate clamps consisting of six segmental shoes, made of aluminum bronze, which clamp the fuel and blanket assemblies into a rigid bundle and also minimize by-pass leakage. These clamps have a hexagonal pattern on their inside edge to fit the blanket assembly tube bundle outline. These shoes are moved in a radial direction by a toggle mechanism buried in the seal plate and operated from the reactor top by a screw and nut actuator. Also in this plate are two throttle valves which are used to control the exit flow from the inner blanket under parallel flow conditions. On top of the seal plate is a thermal baffle cooled by inlet NaK bled through the seal plate. The purpose of the thermal baffle is to reduce the temperature gradient across the seal plate and thus inhibit its warping. Inlet NaK is bled through the seal plate by means of a ring of holes near the outside. The NaK then flows radially inward between the top of the seal plate and the thermal baffle and exits at the inner edge of the thermal baffle into the outlet plenum chamber. Without this thermal baffle it is possible to get a thermal gradient across the plate of about 90°C. With 17.5 gpm of inlet NaK by-passed through the baffle at a total flow of 300 gpm, the calculated gradient is 25°C.

Located above the seal plate is the outlet plenum chamber which collects the flow from the fuel assembly outlet holes and the throttle valves. It is formed by spacer tubes around the tie rods. The outlet coolant line drains this region.

The coolant flow path under each flow condition is as follows:

<u>Under series flow conditions</u> the cool NaK coming in the inlet line is distributed in the annular inlet plenum chamber from which it passes into the inlet valves which will then be in their up position. The NaK enters the upper annular plenum chamber, between the two ring baffles, and then flows into the outer ring of blanket assemblies. The coolant goes down around the blanket rods and into the lower plenum chamber where it is reversed 180 degrees and flows up through the inner seven fuel assemblies to the outlet holes in these assemblies. The flow is then radially outward, through the perforated portion of the blanket assembly, into the outlet plenum chamber and the outlet pipe.

<u>Under parallel flow conditions</u> the inlet valves are in their down position. Flow is then from the inlet valve down into another lower annular plenum chamber just above the mounting plate. Here the NaK is distributed to the twelve downcomers and goes down to the lower plenum chamber. Part of the coolant then goes up through the outer ring of blanket assemblies and out of the holes below the assembly seal plate into the upper annular plenum chamber and then through the throttle valves to the outlet plenum chamber. The remainder of the flow goes through the fuel assembly as formerly described. Under this parallel flow condition the throttle valves may be used to adjust the blanket flow relative to core flow to attain the desired temperature rise across the blanket.

Proper positioning of the valves for either series or parallel flow is assured by limit switches on the valve-actuating mechanism. These switches prevent operation of the reactor and cause a scram if the reactor is in operation, unless either (1) the inlet valves are fully up and the throttle valves completely closed, thus assuring series flow, or (2) the inlet valves are fully down and the throttle valves are opened to a preset minimum, thus assuring parallel flow. Proper valve arrangement is shown by indicator lights in the control room.

The inner tank assembly above the outlet plenum consists of laminated stainless steel shielding, an overflow plenum at the level of the tank overflow line, and the top plate. On this top plate are located the actuators for the core clamp, seal plate clamps, seal rings, inlet valves, and throttle valves. The actuators are all individually operable with an extension wrench during shutdown. However, the throttle valve actuators are mechanically linked by a roller chain. An extension shaft through the top of the reactor tank and the top shield permits flow adjustments during reactor operation.

1. Temperature Instrumentation

The Mark III design includes an extensive system for measuring temperature. Thermocouples are located in the structure, plenum chambers, fuel and blanket rods and in the coolant channels between the rods.

There are eight permanent duplicate thermocouple locations in the structure at points where thermal expansions might lead to reactivity changes, as follows:

- S-1 In vertical center of tube sheet, adjacent to center fuel assembly hole.
- S-2 In vertical center of tube sheet near outside edge.
- S-3 In structural ring at vertical core center line close to downcomer.
- S-4 In structural ring at vertical core center line away from downcomer.
- S-5 In two-inch thick seal plate, 1/4 inch below top, near inner edge.
- S-6 In seal plate, 1/4 inch above bottom, near inner edge.
- S-7 In seal plate, 1 inch below top, near outer edge.
- S-8 In three-inch thick mounting place, $1\frac{1}{2}$ inches from top, $1\frac{3}{4}$ inches from outer edge.

There are four locations in the plenum chambers as follows:

- P-9 In outer inlet plenum, at entrance to inlet valve nearest inlet line.
- P-10 In upper inlet plenum near north throttle valve.
- P-11 In upper inlet plenum near south throttle valve.
- P-12 In outlet plenum near outlet line.

In addition, there are thermocouples in the inlet and outlet NaK lines outside of the reactor tank.

Three fuel assemblies and one blanket assembly have been modified to receive thermocouples, thus allowing a full radial temperature traverse. Thermocouples of various lengths allow axial traverses in the coolant passages between rods.

The thermocouples are of the stainless steel sheathed type with MgO insulation and duplex iron-constantan wire. The hot junction is welded to the inside of the sheath at the tip. All metal temperatures are obtained by sheath tip contact with a NaK heat transfer bond. The rod and core coolant couples have a sheath diameter of 0.040 inch. The structural couples are 1/16 in. in diameter and the plenum chamber couples 1/8 in. in diameter.

There are two types of fuel and blanket thermocouple rods. One, for center rod temperatures, has a central axial hole terminating at the core centerline. The other has an inverted "Y" shaped hole, the two prongs of which terminate at the uranium clad interface, thus giving a temperature gradient across a rod. Vent holes are provided in the thermocouple rods to assure the presence of a NaK heat transfer bond at the sheath tip. Each sheathed thermocouple has a shielded flexible lead wire with a push on-type connector.

On the inside wall of the reactor tank above the top plate of the inner tank assembly is located a gas-tight thermocouple connector box containing 48 hermetically sealed, glass-Kovar-type connectors with iron and constantan contacts. Duplex iron-constantan wire leads from the connectors through a nozzle in the tank shell via a special conduit to a patch board in the control room. The patch board also has iron and constantan contacts with 48 input thermocouple connections and 6 output potentiometer connections.

Six thermocouple amplifiers are provided as well as a six-channel, heated stylus, fast recorder for both experimental temperature and neutron flux measurements.

D. Primary NaK Coolant System

The reactor is cooled by eutectic NaK alloy supplied from a constant level gravity feed tank. Figure 1 is a schematic drawing of the reactor system. Figure 3 is a flow diagram of the NaK cooling systems. After being heated in the reactor it flows through the primary heat exchanger, where it is cooled, to the primary receiver tank. The primary pumps return the coolant to the gravity feed tank. The pumped flow is always larger than the reactor flow, the excess returning from the gravity tank overflow and maintaining a constant level in the gravity feed tank. The lower drain tank of the system has a capacity sufficient to hold all the NaK coolant in the primary operating system. The overflow valve from the lower receiver tank to the drain tank is kept open during all normal operation to prevent a possible high level in the primary mechanical pump and the reactor tank.

An air-cooled convection loop connected between the reactor inlet and outlet takes care of the shutdown decay heat of the reactor. The convection loop inlet valve is manually operated and normally open. The convection loop outlet valve and the expansion tank blanket gas valve have air motor operators driven from an air ballast tank. The motor operators for the two valves are connected in parallel and are actuated from the control room by pushbutton. These valves are normally closed during operation and open automatically upon power failure or failure of reactor coolant flow. If it is desired for the expansion tank gas valve to remain open, the air inlet to its motor should be shut off when it is in the open position. This valve should always be open at reactor flow shutdown to avoid the possibility of a siphoning action dropping the reactor level below the convection loop.

The correct positioning of the internal flow control valves of the reactor for series or parallel flow is necessary. If the blanket throttle valves were open during series flow, the greater part of the core and blanket flow would be by-passed, resulting in high fuel and blanket temperatures.

If the blanket throttle valve were closed during parallel flow operation, the blanket flow would be shut off. If the blanket throttle valve were opened full during parallel flow operation, too large a proportion of the flow would go through the blanket, and high core temperatures would result.

Interlocks prevent operation of the reactor unless these valves are in the correct and proper positions.

E. Secondary NaK Coolant and Steam System

In the secondary system the NaK coolant is pumped directly from the receiver tank through the primary heat exchanger. It is then cooled by flowing through either the steam generator system or the air-cooled NaK load dissipator coils. The secondary system also has a drain tank capable of holding all the NaK in the operating system.

The steam generator is divided into three components: the economizer, boiler, and superheater. A forced circulation, falling film-type boiler is used. The flow of NaK through these units is countercurrent to the flow of water and steam. The steam generated is used in the turbogenerator or passes through back-pressure regulating valves directly into the condenser. The electrical energy generated may be dissipated through air-cooled load dissipator banks or used to supply the plant and building demand. Figure 4 is a flow diagram of the steam system.

F. Load Dissipation System

With the steam generator in operation and with cooling of the secondary NaK, the heat may be removed from the stem by passing all the steam directly into the condenser through the back-pressure regulating valves. Normally, after the steam flow is in excess of 2000 pounds per hour, the turbine generator is started, and electrical load is applied to the generator until most of the steam available is passing through the turbine. A small amount of by-pass flow through the back-pressure regulating valves is always maintained so that the pressure and temperature of the steam in the main will remain constant regardless of electrical demand.

The electrical load is applied to the generator by banks of resistance heaters. They are mounted above the air-cooled secondary NaK coils and are cooled by the same fans. The fan for a particular section of load dissipator must be operating before the load can be thrown in. The cooling fans may be operated either from building power or used as part of the turbine electrical load. If the generator output is sufficient, it may be synchronized with the outside line, the generator switched onto the building load, and the outside line cut off. The reactor and generator then carry the building load.

If it is desired to operate at a low temperature or simply to by-pass the steam generator system, the air cooled, finned tube coils may be used for cooling the secondary NaK circuit. There are four banks of cooling coils. The operating temperature may be adjusted stepwise by using one or more banks of cooling coils.

At fans 1, 2, and 3, the inlet cooling air temperature is controlled by modulating louvers which by-pass part of the outlet air back to the inlet and control the intake of outside cooling air. Number 4 fan has no outlet or by-pass louvers but has steam coils in its inlet. Therefore, it is normally started first as hot discharge; air to the outlet penthouse will by-pass back through it to the fan room if it is not operating. Doors held in place by fusible links will release and isolate the coils in case of fire due to NaK leakage or overtemperature from other causes. Figure 5 is a schematic drawing of the load dissipation system.

G. Reactor System Cooling Air and Ventilation

The reactor cup and control rods are cooled by air drawn through cooling holes in the bricks. The graphite shielding blanket and the elevator and repair rooms have separate exhaust fans. There are filter banks ahead of the suction intakes of the reactor cup exhauster, the graphite exhauster, and the cell ventilation fan serving the elevator repair rooms. These serve to remove particulate contamination of the cooling air, such as might result from cladding failure of a brick in the cup before exhausting to the outside. The rest of the primary cells are cooled by an exhaust blower mounted above the gravity tank room. There is a fan for forced air cooling of the shutdown convection loop, and an emergency reactor blast fan that cools the reactor tank directly if the normal convection loop shutdown cooling should fail. To prevent accidental starting of this fan and thermal shocking of the reactor tank, the stop pushbutton is held closed and must be released before starting this fan.

The reactor supply fan takes outside air through an electrostatic filter and supplies air to the elevator room. The capacity of this fan is less than the high speed capacity of the cup exhauster, and is interlocked so that it cannot be started unless the blanket and shield exhaust fans are operating.

H. Nuclear Instrumentation

A block diagram of the nuclear instrumentation is shown in Figure 6. A brief description of the circuits follows:

Flux Level Trip Circuits

The safety circuits are ANL Model CD-118 Safety Trip Circuits. They have a range of 10^{-12} to 10^{-5} ampere in decade steps and a trip circuit which is adjustable over one decade from the front panel. In normal operation there are three units with their recorders installed, two of which are in operation and one unit as a stand-by.

Period Circuits

The period meters are ANL Model CD-125A and Model CD-125B. The Model CD-125A has a log current range of 10^{-11} to 10^{-3} ampere, a period range of 00 ± 15 seconds and a variable positive period trip of 75 seconds to 15 seconds, adjustable from the front panel. The Model CD-125B has a log current range of 10^{-11} to 10^{-3} ampere, a period range of 00 ± 5 seconds, and a fixed 5-second positive period trip. Both units have an internally adjustable negative period trip. One Brown strip chart recorder is provided for recording periods from either Period A or Period B circuits.

Startup Circuits

Vibrating Reed

The vibrating reed is an Applied Physics Laboratory Model 30. Two input resistors of 10^8 ohms and 10^5 ohms are provided in the electrometer head, giving the instrument a range of 10^{-11} to 10^{-5} ampere. The output of the vibrating reed amplifier is recorded on a Brown strip chart recorder.

Fission Counter

Another startup circuit consists of a fission counter, pre-amplifier, pulse amplifier, and audio pulse monitor. The fission counter is located in the thermal column.

Galvanometers and Automatic Control

The power and differential galvanometers are conventional Leeds and Northrup light beam galvanometers. The automatic control is a relay-type control system actuated by photo-cells mounted on the differential galvanometer scale.

Exhaust Air Activity Monitor

The exhaust air activity monitor consists of an ionization chamber and a linear amplifier having a range of 10^{-12} to 10^{-10} ampere. The output of the amplifier is recorded on a Brown strip chart recorder. Air is alternately cycled through the monitor from the exhaust stack and from the building.

NaK Activity Monitor

The NaK activity monitor measures activity in the gravity feed tank by means of a photomultiplier and NaI crystal and a log amplifier having a range of 10^{-9} to 10^{-3} ampere. The output of the amplifier is recorded on a Brown strip chart recorder.

Ion Chambers

All of the ion chambers are natural BF_3 filled. The galvanometer and vibrating reed circuit chambers are each seven inches in diameter, and the safety and period circuit chambers are each four inches in diameter. All chambers are located in radial holes in the reactor shield.

Chamber Power Supplies

All of the ionization chambers, with the exception of the two galvanometers, are supplied from ANL Model V-93 Chamber Voltage Supplies. The galvanometer chambers and lights are supplied with batteries so that they may continue to function in case of a power failure. A voltmeter and selector switch are provided on the front panel to monitor the chamber supply voltages.

III. REACTOR OPERATION SEQUENCE

The sequence of reactor system operations has been arranged to avoid severe thermal shock to the system components, particularly to the heat exchangers and reactor tank assembly. The following steps must be performed in the order listed. Detailed instructions for each step are given in the following section.

A. Reactor Startup

1a. Steam generator system to be used for cooling - place the steam system, then the secondary NaK coolant system, in operation.

1b. Secondary NaK-air heat exchangers are to be used for cooling - place the NaK-air heat exchangers in operation; then start the secondary NaK coolant system.

2. Place the primary NaK coolant system in operation.

3. Place the reactor cooling air and ventilation in operation.

4. Place the reactor hydraulic system in operation.

5. Fill out the reactor startup check sheet, Appendix "B," and correct any out of order conditions.

6. When operation of all systems is satisfactory as indicated on the check sheet, the reactor is made critical and brought to operating power level.

   a. Series flow
   b. Parallel flow

7. Steam generator system in use for cooling - the turbogenerator is started and electrical load applied.

B. Reactor Shutdown

1. Shut down reactor.

2. Shut down secondary NaK system and steam system.

3. Establish shutdown cooling.

4. Shut down reactor primary system and cooling air.

C. Emergency Reactor Shutdown

1. Interlock scrams.

2. Power failure scram.

IV. REACTOR OPERATION PROCEDURES

A. Reactor Startup Procedure

1. a. Steam System and Secondary NaK System Startup

   (1) Inspect level of water in drum. This should be about half way up on level gage.
   (2) If water is needed, proceed as follows:
       (a) Open globe valve to economizer water inlet.
       (b) Close plug cock to regulator valve.
       (c) Start boiler feedwater pump.
       (d) When level is at the desired point, stop pump and then open plug cock and close globe valve.
   (3) Start boiler circulating water pump.
   (4) Close secondary system NaK pump throttle valve.
   (5) Start pump and immediately open throttle valve to about 25 gpm.
   (6) Proceed to start up of primary system.
   (7) Gradually increase the flow rate to full value at a rate dependent upon the mean temperature difference across the primary heat exchanger (keep below 30°C).

   b. Secondary NaK-Air Heat Exchanger Operating Procedure.

   (1) Outlet valves of cooling coils normally open.
   (2) Open inlet valves on cooling coils that are going to be used.
   (3) Shut steam generator NaK inlet valve V-106 and open load dissipator NaK inlet valve V-108.
   (4) Open steam generator drain valves to avoid a low level alarm in receiver tank.
   (5) Start cooling fans on load dissipator banks in use.
   (6) Close secondary system NaK pump throttle valve.
   (7) Start pump and immediately open throttle valve to about 25 gpm.
   (8) Proceed to start up of primary system.
   (9) Gradually increase the flow rate to full value at a rate dependent upon the mean temperature difference across the primary heat exchanger (keep below 30°C).

2. Procedure for Establishing Flow in the Primary System.

   a. Check the primary tank levels. Gravity tank-full. Receiver tank above 22 inches.

b. Check of flow system operating valves.

(1) Pump suction valves open.
(2) Discharge valve open on operating pump; closed on reserve pump.
(3) Receiving tank overflow valve open.
(4) Reactor overflow valve open.
(5) Gravity tank drain valve closed.
(6) Gravity tank outlet shut off valve open.
(7) Reactor inlet flow control valve closed.
(8) Reactor inlet distribution valves full series or parallel flow.
(9) Blanket flow throttling valve: Closed for series flow; throttled for parallel flow; locked in position.

c. Start the primary pump and adjust the flow to at least 50 gpm greater than the desired reactor flow. The EM pump discharge valve must be at least 10% open during operation of that pump.

d. Start the reactor flow at about 25 gpm.

e. Close convection loop outlet valve V-4 and expansion tank blanket gas valve V-204; both on V-4 pushbutton.

f. As the reactor and primary heat exchanger approach the inlet NaK temperature, gradually increase the flow rate to full flow. Allow 10 to 15 minutes for warm up.

(1) Keep the mean temperature difference across the heat exchanger within 30°C during the warm up period.

3. Procedure for Establishing Reactor Cooling Air Flow.

a. Start building ventilation.
b. Start cell ventilation
c. Start graphite or upper blanket exhauster.
d. Start reactor cup exhauster.
e. Start reactor supply air.

4. Procedure for Operating Reactor Hydraulic System

a. Start elevator hydraulic pump.
b. Press reactor reset switch.
c. Move blanket safety block up.
d. Run all safety rods to up position.
e. Place control rods at 15-inch position.
f. Move elevator switch to up position.
g. After elevator reaches the jacks, control its position by the jack operator switch.

5. a. Series Flow

(1) Check inlet distribution valves and blanket flow throttling valves for proper series flow position.
(2) Fill out reactor start up check sheet.
(3) Bring elevator to the jacks with safety rods up and control rods at 15 inches. After elevator is on the jacks, place the elevator switch in the neutral position and move control rods one at a time to up position.
(4) Move jacks carefully toward estimated critical position, while continually noting audible fission counter, vibrating reed recorder, and other flux indicators.
(5) After reactor is critical adjust to period of 40 to 60 seconds.
(6) Record period from each scale of the vibrating reed recorder as the reactor power rises.
(7) After the range of the vibrating reed recorder is passed, observe power level on the power level galvanometer.
(8) Adjust reactivity with control rods and jacks as necessary to attain desired operating power level.
(9) When desired power level is approached, adjust control rods and jack position until power is stable at desired power level.
(10) Adjust differential power galvanometer to operating position.
(11) Adjust reactivity as necessary until operating temperature level is reached.
(12) After reaching operating temperature level, switch to automatic control if desired.

b. Parallel Flow

(1) Check inlet distribution valve and blanket flow throttling valve for proper parallel flow position.
(2) Fill out reactor startup check sheet.
(3) Bring elevator to the jacks with safety rods up and control rods at 15 inches. After elevator is on the jacks, place the elevator switch in the neutral position and move control rods one at a time to up position.
(4) Move jacks carefully toward estimated critical position, while continually noting audible fission counter, vibrating reed recorder, and other flux indicators.
(5) After reactor is critical adjust to period of 40 to 60 seconds.

(6) Record period from each scale of the vibrating reed recorder as the reactor power rises.
(7) After the range of the vibrating reed recorder is passed, observe power level on the power level galvanometer.
(8) Stabilize the reactor power as soon as there is an appreciable temperature rise across the reactor - say 20°C.
(9) If temperature rise across blanket and core are not equal, adjust blanket flow to make them equal. Then increase power.
(10) Adjust reactivity with control rods and jacks as necessary to attain desired operating power level.
(11) When desired power level is approached, adjust control rods and jack position until power is stable at desired power level.
(12) Adjust differential power galvanometer to operating position.
(13) Adjust reactivity as necessary until operating temperature level is reached.
(14) After reaching operating temperature level switch to automatic control.
(15) Check core and blanket outlet temperatures carefully as power is increased and make final adjustments in blanket flow at stable operating condition.

6. Steam System and Turbogenerator Startup

a. When steam pressure reaches 150 psi, close the manual switch for the deep well pump. The pump runs steadily, and the back-pressure regulating valve puts cooling water through the condenser into the sump.

b. Start one hot well condensate pump. Its throttle valve should be open about 1/3 turn.

c. Start air ejector by opening main steam valve to air ejectors.

d. Start the automatic feed water regulator as follows:

(1) Open globe valve to economizer inlet.
(2) Start boiler feed water pump.
(3) Crack open regulator generator vent valve and allow to bleed slowly until regulator functions properly.

e. Blowdown gage cocks to make sure they are clean and functioning properly.

f. Open valve supplying gland steam from low pressure line. See that bleed of valve from gland line is closed.

g. When pressure reaches 400 psi, the back-pressure regulating valve should start passing steam, and the condenser vacuum should be above 20 inches of mercury.

h. When at least 2000 pounds of steam per hour are flowing, as indicated in the control room, the turbine may be started as follows:

i. Check level of oil in sump and at both generator bearings. Add oil to governor oiler if necessary.

j. Blow down steam line by opening throttle strainer drain valve until water ceases to flow and then shut it.

k. Start oil pump motor. When bearing pressure reads 5 psi, inspect to see that oil is flowing through the sight glasses at the reduction gear bearings.

l. Open steam throttle valve very slowly.

m. When turbine starts to rotate, control throttle valve to slowly increase speed. At full speed, the governor should take over and hold speed of generator at 1200 rpm.

n. When it is seen that governor is working, open throttle valve fully.

o. Stop oil pump motor.

p. Close gland steam valve from low pressure steam system.

q. Maintain gland steam pressure at 2 psi by opening the bleed off valve.

r. Open water valve to oil cooler when temperature of oil inlet reaches 100°F.

s. Electrical load may be put on unit after it has run at least 5 minutes.

(1) Load dissipators:
- (a) Close field switch.
- (b) Adjust voltage to 480 v.
- (c) Close turbogenerator breaker.
- (d) Switch load dissipator fans to turbogenerator.

(e) Start cooling fan that cools load dissipation heaters for desired electrical load.

Selector Switch Position	Load, kw	Fan Required
Sel. Sw. #1; 1-8	80	#1
Sel. Sw. #1; 9-10	20	#2
Sel. Sw. #2; 1	100	#2 and #3
Sel. Sw. #2; 2	100	#3 and #4

(f) Load turbogenerator until only a small amount of steam is being by-passed.

(2) Building Load.
To switch from load dissipators to building load when generator output is sufficient:
(a) Synchronize turbogenerator with incoming line.
(b) Adjust voltage to that of incoming line.
(c) Close circuit tie breaker.
(d) Remove artificial load from turbine.
(e) Open breaker on incoming line.

(3) To transfer building load back to incoming line:
(a) Synchronize turbogenerator with incoming line.
(b) Adjust voltage.
(c) Close circuit breaker in incoming line.
(d) Open turbogenerator circuit breaker.

B. Procedure for Reactor Shutdown

1. Reactor Shutdown

a. Lower reactor power level slowly, particularly at the higher power levels. Take 10 to 15 minutes to bring reactor power to low level.
b. Drop safety rods out one at a time.
c. Drop reactor outer blanket.
d. Stop elevator hydraulic pump.

2. Secure Secondary NaK System and Steam System.

a. Unload generator slowly. At no load, governor should hold frequency of 60 cycles.
b. Wait until reactor is shut down.
c. Stop secondary NaK pump.
d. Close turbine throttle valve.
e. Close water valve to oil cooler.
f. Stop boiler water circulating pump.

g. Stop boiler feed water pump.
h. Close globe valve to economize water inlet.
i. When no steam is blowing off to condenser, shut off steam to air ejectors.
j. Stop hot well condensate pump.
k. Turn off manual switch for the deep well pump.
l. On Fridays, blow boiler down, after being secured, as follows:
   (1) Open outer quick opening blow down valve.
   (2) Slowly open inner blow down valve until water is flowing out of the drum.
   (3) When drum is empty, close both valves.
   (4) They may be left open until the next start up.

3. Establish Shutdown Cooling.

a. Continue reactor cooling flow for 5 to 10 minutes at 200 gpm.
b. Open convection loop outlet valve and expansion tank gas valve and allow NaK to flush through convection loop.
c. Close reactor NaK flow control valve.
d. Natural convection of cooling air over the convection cooling coil is sufficient for the shutdown cooling load. The convection cooling fan is used if a higher cooling rate is desired.

4. Stop Primary NaK Pump.

5. Stop Reactor Cooling Air.

6. Lock Control Panel.

7. Observation of reactor temperature and convection flow rate shall be continued until it is assured that temperatures are dropping and flow is established before operators are free to leave.

C. Emergency Reactor Shutdown

1. Interlock Scrams.

a. Startup of reactor after interlock scram.
   (1) Determine and correct the cause of the reactor scram before attempting further reactor operation.
   (2) Follow normal reactor startup procedure as outlined previously.
b. Shutdown of reactor system after interlock scram.
   (1) Follow normal reactor system shutdown procedure from this point.

2. Reactor Shutdown Due to Power Failure

a. In case of an emergency shutdown of the reactor due to a power failure, or of any failure of the motorized valve operators, manual operating wheels in the control room are provided for the main reactor flow valves. These valves are:

(1) Gravity tank outlet shutoff valve V-1.
(2) Reactor flow control valve V-2.
(3) Gravity tank drain valve V-11.
(4) Convection loop outlet valve V-4.

b. (1) If power failure occurs at full power the reactor flow may be throttled to provide 30 minutes of cooling flow at 100 gpm from the gravity feed tank before the convection loop must take care of the shutdown cooling load. The convection cooling system will easily handle the load 10 minutes after shutdown.
(2) If the reactor is sub-critical or at low power at the time of power failure, the reactor flow may be shut off immediately to prevent dropping NaK into the drain tank.

c. Only in case of a NaK leak in the reactor tank or piping should it be necessary to use the gravity tank drain valve and drop all NaK into the primary drain tank.

d. As the convection loop outlet valve is air motor operated, and automatically opens on power failure, manual operation would be needed only if it is desired to close this valve while the power is off, or in case of failure of the air motor valve operator.

V. AUXILIARY OPERATION OF THE REACTOR SYSTEM

Before starting operation of the reactor on Monday of each week, the reactor interlock system shall be checked and the form specified in Appendix "C" filled out. Items starred may be omitted, except on the first check of each month, upon the discretion of the chief operator.

A. Interlock Check

1. Interlock Check Sheet

2. Interlock Check Procedures

This section is intended to cover those sections of the interlock check procedure not covered in normal operating instructions.

a. Reactor Section

(1) Nos. 9-13, Safety Circuit Interlock Check.
In checking each safety circuit, set the corresponding trip level one decade below normal. Make the reactor critical and raise power slowly through the trip point. Reset trip level to normal after each test.

(2) Nos. 14-19, Period Meter.
- (a) Place reactor on a stable period close to 30 seconds. (If it is desired to check another range of the period meter, place the reactor on a period close to one of the index marks in the period meter.)
- (b) Record one or two good periods in the lower range of the vibrating reed recorder.
- (c) Move the pointer on the period meter dial slowly toward the indicated period until the trip point is reached.
- (d) After the reactor has tripped, record the period from the vibrating reed recorder and the trip position of the period meter dial pointer.

(3) No. 20, Automatic Control.
- (a) Reset control panel.
- (b) Switch on automatic control.
- (c) Shine light on upper control photo cell and check time to scram - 2 minutes. Repeat on lower control photo cell.

(4) No. 24, Low Compressed Air Supply
- (a) Shut off air supply to air ballast tank.
- (b) Bleed pressure and observe tank pressure when alarm trips.
- (c) Shut off bleed and open air supply.

b. Coolant Section

(1) Nos. 3, 4, 5, 6, 21, 22 and 26, Flow Alarms.
Coolant flow alarms are pointers set on the corresponding recorders.

(2) Nos. 9 and 10, Over-Temperature Alarms
(a) Stop the recorder drive on one of the numbers reading the desired temperature.
(b) Insert the jack connector from the variable potentiometer provided, and drive the recorder pen up scale until the alarm point is reached.

(3) NaK Level Indicator Alarm.
Gravity tank level alarm shall be checked by dropping level to alarm point.

All other alarms shall be checked by operating test switch on rear of level detecting chassis.

3. Nuclear Instrumentation Calibrations and Checks

a. Safety Circuits

(1) Zero with reactor not operating.
(a) Place range selector switch on 10^{-5} amp.
(b) Unlock "Zero" dial and adjust for zero on meter.
(c) Lock dial after adjustment and return range selector switch to normal position.

(2) Trip and Range Selector
(a) Determine, from calibration curves, chamber current for desired operating power.
(b) Set the normal trip point 20% above the current obtained in Step (a).
(c) Set range selector switch for current range determined in Step (b).
(d) Unlock "Trip" dial and set for range multiplier determined in Step (c).
(e) Note "Trip" dial calibration of 0 to 10 corresponds to meter calibration of 0 to 100.
Example:

Desired operating power	1 Mw
From calibration curves	1 Mw = 0.5×10^{-6} amp.
Trip point 20% above normal of	0.6×10^{-6} amp.
Set range selector at	10^{-6} amp. position
Set "Trip" dial at	6

(3) Trip Dial Check
   (a) Set trip dial at 5 (corresponding to 0.5 on meter)
   (b) Set range selector switch on 10^{-5}.
   (c) Unlock "Zero" dial and rotate so that meter reading increases.
   (d) As meter is moved through 0.5 with zero dial observe trip light.
   (e) If trip does not occur at meter reading of 0.5, call Electronics to calibrate "trip" dial.
   (f) After check return "Zero," "Trip," and "Range Selector Switch" to normal; lock all dials.

b. Period Meters

(1) Period A:
Trip: Period Meter A may be set to trip on any period from +75 sec to +15 sec. The negative period is fixed at -15 sec.

(2) Period B:
Trip: Period Meter B has fixed +5-sec trip. The negative period trip is fixed at -5 sec.

(3) Log Current Calibration
   (a) Remove chamber current cable from log amplifier (log amplifier is located on main floor reactor face).
   (b) Set calibration switch to 10^{-9} amp position and observe log current meter on chassis in control room. It should indicate a current of 10^{-9} amp.
   (c) Repeat Step (b) for 10^{-5} amp.
   (d) If log current meter is not correct at 10^{-9} or 10^{-5} amp, call Electronics to calibrate log amplifier.
   (e) If calibration is correct, return the calibration switch to its normal position and reconnect the chamber current cable.

(4) Trip Calibration
   (a) Place the period selector switch in its +T position (located on rear of period meter chassis).
   (b) Adjust the +T Adj. to obtain the desired period and observe the +trip light. (+T and -T Adj. located on rear of period meter chassis).
   (c) Repeat (a) and (b) for -T.
   (d) Trips should occur as follows:

	Period A	Period B
Positive	+75 to +15 sec	+5 sec
Negative	-15 sec	-5 sec

(e) If trips are in calibration, return period selector switch to its position. If trips are not correct, call Electronics to calibrate.

c. Chamber Voltage Supplies

(1) Electronic Supplies
Rotate meter switch through all of its positions. All supplies should measure 600 volts.

(2) Battery Supplies
Each battery supply has a voltmeter which is activated by a pushbutton located next to the meter. Both supplies should measure 600 volts.

Warning

During operation of the reactor the meter switch should be left in its off position. There is a slight loading effect on the chamber voltage supplies caused by the voltmeter. This loading can disturb the period meters and safety circuits sufficiently to cause a scram.

d. Vibrating Reed

(1) Zero:

(a) Place shorting switch in short position; place range switch in 1 mv position; with zero control set meter at zero.

(b) Place shorting switch in non-short position. Instrument is now ready for use.

e. Power Galvanometer

(1) Zero:
Place shunt switch in short position. Adjust scale position so that the hair line is on zero. Return switch to operating position.

B. Procedure for Access into Reactor Top

1. Description

It is necessary to open the top of the reactor tank to operate the inlet flow control valves, core clamp, seal plate clamps, to make loading changes, and for the insertion of irradiation samples or equipment for special experiments. During these operations, the reactor must be not operating, and the primary coolant system must be shut off.

To open the reactor it is necessary to drop the blanket gas pressure to slightly above atmospheric and, after the reactor is opened, to bleed blanket gas in through the flushing line to prevent inleakage and contamination by air. The reactor tank may be isolated from the rest of the system, and the gas from it bled off. However, if the reactor isolating valves were not completely tight, the reactor level of NaK might rise into the upper compartment under these conditions because of differential gas pressure. Therefore, this method is not to be used.

The procedure used is to isolate the primary system from its drain tank and to pump the primary blanket argon into the drain tank to retain it. When the reactor is closed up this gas is released back into the system, and the drain tank opened to the primary system again.

The gas bleed should be increased with larger opening of the lid. The size of the opening and the length of time the reactor is open should be kept to the practical minimum to avoid contamination of the reactor system by air as far as possible. It is advisable to bleed gas through a small opening in the reactor lid for a time if a large opening in the reactor lid has been exposed for some time.

After closing the reactor care should be taken to bleed the gas in slowly from the drain tank and not to open the large receiver tank overflow valve first. If this is done, a pressure surge results in the receiver tank which may force NaK in the primary mechanical pump above the pump flange and into the motor compartment.

2. Procedure for Opening Reactor Tank Cover.

   a. Shut off reactor gas circulating pump. This is interlocked and will be shut off by the low blanket gas pressure alarm if K panel power is on.
   b. Close receiving tank overflow valve V-15.
   c. Close drain tank blanket gas valve V-215.
   d. Shut off reactor blanket gas at gas distribution panel V-201.
   e. Open shutoff valves on gas transfer pump.
   f. Start gas transfer pump.
   g. When primary blanket gas pressure reaches 0.1 to 0.2 psig, shut off gas transfer pump and close its shutoff valves.
   h. Start and adjust flow of reactor flushing gas.
   i. Open plug in cover.
   j. Release cover hold downs.

3. Procedure for Closing Reactor Tank Cover and Reinstating System.

   a. Close reactor cover and tighten hold downs.
   b. Vent flushing gas through plug in cover as necessary to remove air.

c. Close plug in cover.
d. Shut off reactor flushing gas.
e. Open drain tank blanket gas valve V-215, slowly, and allow system gas pressure to equalize.
f. After pressure is equalized, open receiver tank overflow valve V-15.

C. Procedure for Operation of Reactor Internal Mechanisms

1. Seal Ring Operators

To tighten:

a. NW operator - counter clockwise
b. SE operator - clockwise

2. Seal Plate Shoes

To tighten: counter clockwise 3 plus turns from open position.

3. Core Clamp

To tighten: clockwise 17 turns from open position.

4. Inlet Valves

a. Series flow: up counter clockwise
b. Parallel flow: down clockwise

5. Throttle Valve

a. Series flow: closed - down clockwise
b. Parallel flow: partially open - up counter clockwise

D. Procedure for Loading

1. Cold Fuel Assembly

A non-radioactive fuel assembly may best be loaded by supporting it at a slight angle above horizontal and inserting rods a row at a time, starting at the bottom. The rod sheet at the bottom of the fuel assembly should be checked periodically to insure that the triangular rod tips are located in the proper holes. The tightening rod should be inserted in the central rod location in the normal sequence.

After the fuel assembly is completely loaded, attach the lock plate and lifting head using an assembly manipulator. First start the tightening nut on tightening rod. Engage the pins on the manipulator through the bayonet slots on the lifting head. Insert the lock plate into the top of the fuel assembly until it rests on the tabs. Twist the lock plate to engage the slots in the hex tube wall and then tighten the lock screw with the attached Allen wrench. Start and turn down the tightening nut with the torque wrench until a torque of 30 inch pounds is applied.

2. Cold Blanket Assembly

A blanket assembly is loaded in a similar manner, except that the upper portion of the assembly must be removed by taking out the three flat head screws at the seal plate joint. Load in the short blanket rods and long blanket tightening rod as before. Replace upper portion of blanket assembly by slipping it over the tightening rod and fastening the screws. Start the tightening nut on tightening rod at top of assembly and tighten nut using assembly manipulator to 30 inch pounds of torque.

3. Cold Reactor Loading

To load an assembly into the reactor, use an assembly manipulator and the building crane to lower the assembly into its proper location in the inner tank assembly. Make sure the assembly is properly oriented. When all assemblies are in place, tighten seal plate and core clamps consecutively, a little at a time, until all position indicators read the same and clamps are tight.

4. Hot Loading

A change in load in any of the seven fuel assemblies after the rods are radioactive may be done either by changing individual rods or a whole fuel assembly.

5. Hot Individual Fuel Rod

To change an individual rod remove the top shield, cover plate and oscillating rod, and/or throttle valve shaft, if necessary. Engage lifting head on assembly with assembly manipulator. Loosen and remove tightening nut with socket wrench. Loosen lock screw with Allen wrench, rotate lifting head to disengage slots, and lift out. Top of fuel rods are now exposed. Engage top of fuel rod with rod manipulator. Lift rod until it is near top of shield, clamp it to hold, and disengage rod manipulator. Align rod coffin over rod. Drop hoist cable through bottom of coffin and engage coffin grapple to top of rod; tighten hoist cable, remove clamp, and lift rod into coffin which has argon gas bleeding into it; close bottom coffin door. Coffin can then be transported to washroom and rod farm.

To load a rod, reverse the procedure, using the rod manipulator alone if rod is cold and the rod coffin if rod is radioactive. When using the coffin to load a rod, an aluminum rod is threaded into the top of the rod clamp in place of the coffin hoist cable. The operator guides the fuel rod into place and lowers it out of the coffin into the reactor from his position on top of the coffin. The aluminum rod is then disengaged and the coffin removed. Replace center hole cover and top shield.

Important. To prevent misplacement of rods in assembly, remove and replace only one rod at a time.

6. Hot Assembly

A radioactive fuel or blanket assembly should be removed by the following procedure: Remove top shield, cover plate and oscillating rod, and/or throttle valve drive shafts, if necessary. Loosen core and seal plate clamps. Align assembly coffin over desired assembly with assembly grapple hanging below it. Using assembly grapple handle engage grapple to lifting head. Remove handle from grapple and raise assembly into coffin which has argon bleeding into it. Shut coffin door and transport coffin to washroom and storage holes.

To load a radioactive assembly, reverse procedure.

7. Hot Blanket Rods

Short blanket rods cannot be reloaded in the reactor. The blanket assembly must be removed from the reactor, washed, and inserted in a storage hole which has a special short liner tube that will locate the seal plate joint in the blanket assembly just above floor level. Remove the tightening nut on top of the assembly and the three flat head screws at the joint. The upper part of the blanket assembly can then be lifted off exposing the tops of the blanket rods. The rods may then be handled in a normal manner. If a rod coffin is used, the tightening rod should be removed.

Remove and replace only one rod at a time.

Reverse the procedure to load a radioactive blanket rod and assembly.

E. Washing Rods and Assemblies

Following its removal from the reactor, the rod or complete assembly must be washed free of NaK before being placed into storage.

This is accomplished by lowering the rod into the washroom and dipping consecutively into alcohol, water, and acetone.

In the case of a single rod, the remote control switch may be used for the dipping operation, which is viewed through the washroom shield window.

The assembly must be manipulated manually at the coffin by an operator who is in communication with the man at the shield window.

Rods and assemblies should be held over the top of each thimble until it ceases to drip before being moved.

F. Loading Diagram, Fuel Rod Records, and Control of Material

The inner tank assembly is oriented so that one centerline across corners of a hexagonal subassembly is in line with building north. The north corner of the assemblies will be identified for proper orientation upon installing. The assembly positions are lettered A at the center, consecutively clockwise from the north-south center (see Figure 7). The individual rods in an assembly are numbered from the rod in the northern corner of the assembly (see Figure 8).

Careful, complete, and current records shall be kept of the reactor core and blanket loading. Complete and current records shall be kept of all individual fuel rods as to location in the reactor or storage areas and time in reactor. This shall be the responsibility of the Chief Operator.

No fuel or blanket material shall be removed from or placed into the reactor, storage area, or vault without the presence of a Special Materials Representative. He shall keep independent records of material location in addition to those kept by the operating crew.

G. Procedure for Transfer of NaK from Drain Tanks to Operating Systems

When all or part of the NaK in the operating system has been dropped into the drain tank it must be returned to the operating system. In the primary system this is generally done with the electromagnetic NaK transfer pump mounted on the floor alongside the drain tank. This system is shown in Figure 9. The pump has a U-shaped overhead suction line which must be vented of gas and filled with NaK before the pump is operated. The pressure in the vent tank, mounted on floor beside drain tank entrance, is reduced to 0 psig by venting to atmosphere and is then closed off. It is then opened to the pump suction line until the pressure in the system balances the pressure in the vent tank plus the NaK head in the suction line. This process is repeated until the pump suction line is fully vented.

The pump will then operate at a flow above the low flow interlock trip. The vent tank probe should be checked with a continuity meter during venting to prevent filling it with NaK. The gas pressure in the system may not be high enough to completely vent the suction line of the pump. In this case, the system pressure may be raised or the drain tank isolated and the pressure in the drain tank raised. The NaK is usually pumped into the receiver tank, and the primary pump operated intermittently to transfer it to the gravity tank.

NaK may be transferred by isolating the drain tank and pressurizing it above the rest of the system either with the blanket gas transfer pump or with the transfer gas regulator.

In the secondary system NaK must be transferred from the drain tank by pressurizing the drain tank above the system pressure and transferring through the receiver tank drain valve. Detailed instructions are given in the following outlines:

1. Primary System

   a. Operation of NaK Transfer Pump.

      (1) Vent gas from pump suction line into vent tank mounted on floor beside drain tank floor entrance.
         (a) Bleed vent tank to 0 psig and close.
         (b) Open vent tank to suction line.
         (c) Check vent tank probe with continuity meter for NaK level while venting.
         (d) Close vent tank to suction line.
         (e) Bleed vent tank to 0 psig.
         (f) Repeat until suction line is vented.
         (g) If gas pressure is too low for proper venting of suction line, increase the system pressure 1/2 to 1 psig or isolate the drain tank and increase pressure in the drain tank until the pump is vented and operating properly. The drain tank is then reopened to the system.
      (2) Open NaK transfer valve V-27 to receiver tank.
      (3) Start pump.
      (4) Repeat procedure until it pumps at a rate above low flow trip point.
      (5) Operate primary pump intermittently to transfer NaK from the receiver tank to the gravity tank. Do not lower receiver tank level too far or primary E-M pump will lose suction.
      (6) Operate NaK transfer pump until primary tanks are filled to the required level.
      (7) Close V-27.

b. Transfer of NaK with Gas Transfer Pump.

(1) Open V-27 NaK transfer valve.
(2) Isolate drain tank and pump blanket gas into drain tank as in Procedure for Opening Reactor Tank.
(3) Operate primary pump intermittently to transfer NaK to gravity tank. Watch receiver tank levels carefully.
(4) After primary system tanks are full shut off V-27 and gas transfer pump.
(5) Equalize system pressure and open receiver tank overflow valve as described in procedure for opening reactor tank.

c. Transfer of NaK with High Pressure Transfer Gas.

(1) Close receiver tank overflow valve V-15 and drain tank blanket gas valve V-215.
(2) Close blanket gas shutoff at panel V-201.
(3) Open V-27 NaK transfer valve.
(4) Open transfer gas valves and adjust regulator above 15 psi. Gas pressure in drain tank will force NaK into receiver tank.
(5) Operate the primary pump intermittently to transfer NaK from the receiver tank to the gravity tank. Do not lower receiver tank level too far or primary electromagnetic pump will lose suction. Do not allow level to reach the high alarm point.
(6) After tanks are full, shut off transfer gas valve V-203 and NaK transfer valve V-27.
(7) Open drain tank blowoff valve V-216 and release excess pressure to stack.
(8) Open drain tank blanket gas valve V-215 and receiver tank overflow valve V-15.
(9) If system blanket gas pressure is higher than desired, blow off excess through V-216.

2. Secondary System

a. Close secondary blanket gas valve at distribution panel V-301.
b. Close drain tank blanket gas valve V-303.
c. Open secondary transfer gas valves at gas distribution panel and adjust pressure regulator above 5 psi in excess of blanket gas pressure.
d. Open transfer gas valve in cold pump room V-305.
e. Open shutoff between drain tank and receiver tank V-111.
f. Excess gas pressure in system blanket gas may be released through blow off valve in cold pump room.

g. When high pressure gas from drain tank bubbles through into receiver tank close shutoff valve V-111.
h. Close transfer gas valve V-305.
i. Open drain tank blanket gas valve V-303.
j. Close transfer gas shutoff valves at gas panel.
k. Open blanket gas shutoff valve at gas panel V-301.

H. Electrical Heating of NaK Systems

It is sometimes desired to heat the reactor system without operating the reactor. To do this, 90 kw of electrical heaters are provided in the secondary NaK systems. By-pass steam generator and load dissipators, and open the line leading directly from the primary heat exchanger to the receiver tank. Place the flow systems in operation and turn the heaters on. They can raise the reactor system to about 320°C before heat losses prevent higher temperature.

This system consists of three 30-kw heaters which may be operated separately by the use of their breakers, which are located in the secondary pump room.

1. Procedure for Heating Primary NaK System with Secondary Electrical Heaters.

a. Close steam generator inlet valve V-106 and load dissipator inlet valve V-108.
b. Open secondary by-pass valve V-103 in cold pump room.
c. Establish primary and secondary NaK flow.
d. Place heaters in operation until system temperature reaches desired value.

I. Procedures for Adding NaK to the Coolant System

The NaK alloy is received in stainless steel drums having a NaK connection going to the bottom of the barrel and a blanket gas connection open at the top. Vent the gas connection in the drum to 0 psig, and connect the NaK line to the fill valve of the system by pipe having considerable flexibility to permit weighing. Pressurize the NaK drum two to three pounds above the system blanket gas pressure with inert gas. The barrel has been placed on a platform scales and is continuously weighed. Record all additions and removals of NaK from the systems in the reactor log. In the primary system the NaK may be put directly into the drain tank by opening V-13, through the fill filter into the drain tank through V-12, or into the receiver tank through V-27. In the secondary system the NaK goes directly into the drain tank.

After emptying a drum, release the gas pressure and disconnect the piping to the system. Pressurize the drum with 5 psig of inert gas, close all valves, and replace pipe plugs and caps where required. Detailed instructions are in the following outline:

1. Primary System

   a. Place NaK drum on platform scales.
   b. Release gas pressure on drum and connect the NaK connection on the barrel with the system fill valve V-26.
   c. Pressurize NaK drum 2 to 3 psig above blanket gas pressure with argon gas through gas regulator.
   d. Open NaK transfer valve V-27 to receiver tank.
   e. Take gross weight of NaK drum.
   f. Open NaK fill valve V-26.
   g. Empty drum.
   h. Shut off V-26.
   i. Take tare weight of NaK drum.
   j. Vent gas pressure on NaK drum and break connection with V-26.
   k. Close NaK drum and pressurize 5 psig with argon gas.
   l. Close NaK transfer valve V-27.

2. Secondary System

   a. Place NaK drum on platform scales.
   b. Release gas pressure on drum and connect the NaK connection on the drum with the system fill valve V-115.
   c. Pressurize NaK drum 2 to 3 psig above blanket gas pressure with argon gas.
   d. Take gross weight of NaK drum.
   e. Open NaK fill valve V-115.
   f. Empty drum.
   g. Shut off V-115.
   h. Take tare weight of NaK drum.
   i. Vent gas pressure on NaK drum and break connection with V-115.
   j. Close NaK drum and pressurize 5 psig with argon gas.

VI. REACTOR CONTROL SYSTEM MAINTENANCE

A. Maintenance and Adjustment of Outer Blanket Hydraulic System

A schematic drawing of the reactor hydraulic system is shown in Figure 10.

The only routine maintenance necessary is to keep the oil reservoir full. With the pump off, the oil level should be visible in the sight glass.

In normal operation the high-pressure limit switch shuts the pump off at 1200 psi, and the low limit switch turns it on at 950 psi. At 890 psi the elevator drops away from the limit switches, and a scram results. On an electrical scram two solenoid-operated valves open, and the oil from the ram returns to the reservoir through a 3-inch return line. After the elevator falls about 30 inches, two chain-driven throttle valves start to decelerate the elevator. After about 50 inches of fall, four hydraulic snubbers finish slowing the assembly to a stop. The brass valve in the oil-return line is used to hold the elevator up when working in the elevator room and must be unlocked before it can be operated.

The padlocked angle valve on the high-pressure line is set to limit the speed of a manual scram. The relative speed of different elevator scrams can be seen in Figure 11.

If the cooling water in the oil reservoir should fail, the bulk temperature of the oil will rise. Under these conditions the viscosity change is enough so that excessive leakage will drop the pressure below 890 psi, and a scram will result. Restoring normal cooling flow will remedy this trouble.

B. Service and Maintenance of Reactor Control and Safety Rods

When operating at power the safety rods will require fairly frequent service due to heat and radiation damage suffered by the grease used in the safety rod dashpots. Occasional mechanism failures will also require service. While working on this equipment the following procedures are used:

1. Preparation for Working on Control Mechanisms

   a. To service the safety and control rod drives the elevator should be run up to the jacks.
   b. Unlock the 3-inch brass hydraulic valve in return line.
   c. Close this valve. This will keep the elevator up in case of a power failure.

d. Open the elevator shielding door and use a hand monitor when entering the elevator room.
e. Place the 3-inch pipe supports under each side of the elevator platform.
f. Have the operator in the control room push the "scram" button.
g. Slowly open the 3-inch brass valve and let the elevator settle on the pipe supports.
h. Close the valve again.

2. Lubrication of Dashpots

If a safety rod does not reach its bottom limit, it is probable that the grease in the dashpot has become gummy, and the rod is sticking above its bottom position. The dashpot is first washed with trichloroethylene put in with a small tube inserted through the bottom of the dashpot. A small amount of lubricant is then injected until the dashpot is operating properly with the safety rod reaching its bottom limit.

3. Adjustment of Safety Rod Spring Tension.

If a safety rod will not stay in its upper limit position, it indicates that there is too much spring tension. With the rod in its bottom position the rack and pinion are disengaged, and the spring tension backed off in quarter-turn increments until operation is satisfactory.

4. Removal of Dashpots or Safety Rods

The safety rod is first disengaged from the drive rack. The drive mechanism is removed. At this time the safety is supported by the dashpot. Next a threaded support rod is brought through the elevator platform and connected to the safety rod. Slightly raising the safety will make the removal of the dashpot screws easier. Next the dashpot is allowed to slide down the support rod until it rests on the platform. The safety rod is then held with a forked bar while the support is unscrewed and the dashpot replaced. For complete removal of the control rod the small rod coffin is moved into place under the elevator platform. The threaded rod passes through the coffin and connects with the safety rod. The safety is then lowered into the coffin from below, and the threaded rod is removed. A new control rod is installed in the reverse order.

5. Return of Reactor Outer Blanket Elevator to Operating Condition.

After work is completed the elevator is placed in operating condition again.

a. The elevator is raised back to the jacks.
b. The pipe supports under the elevator are removed, and all tools and equipment are removed from the elevator room.
c. The elevator room shield door is closed.
d. The 3-inch brass valve in the return line is opened and locked in position. The elevator is now in operating condition.

C. Reactor Cup Removal and Repair Room Operation

1. With elevator in the down position install horse shoes on elevator extensions in pit below the elevator room.

2. Run elevator up until the horse shoes stop it (about 4 inches). Be sure safety and control rods and plug are down. It is now in position to bring the transfer carrier from the repair room and engage the breeding blanket.

3. Unlock and energize repair room panel.

4. From control panel at the repair room, lower lead shielding door between repair room and the elevator room.

5. Move transfer carrier into elevator room (left) until out of sight.

6. Mount ladder in front of elevator room and use the dual controls to engage the transfer carrier. The shielding window at this position gives an excellent view of the carrier and cup.

7. When carrier is in position, lower the elevator slowly, and the breeding blanket will remain on the carrier.

8. Return to the main control board and run the carrier into the repair room (right) until it is past middle of the room.

9. Turn the track stop switch "on" and move the carrier slowly left until it hits the stops.

10. The hydraulic pump unit conveyor, type 2, should be turned on with pushbotton near key switch.

11. The repair room vertical conveyor then can be started by pushing the 3-position switch to "raise" position and pushing speed switch to "normal." Before raising the conveyor ram, the load platform should be rotated so that the red mark indicating the dowel hole is directly in front of the north viewing window, and the index lock engaged in this position (Note: Index slots are 30° apart). This places the ram in the correct position to engage the dowels on the outer blanket, or the cup in correct position for replacement on the reactor elevator.

12. Just before the ram picks up the blanket, change the speed switch from "normal" to "slow." Watch to see that alignment of dowels is correct. Carefully lift the cup about one-fourth inch off the carrier.

13. Back the transfer carrier out of the way (right) and lower the ram.

14. With the blanket in the down position the manipulator bridge can be moved to engage the tool used for removing the aluminum sleeve around the blanket bricks.

15. Remove the sleeve; place it well to one side.

16. Disengage the tool from the manipulator and pick up the mechanism for pulling the aluminum liner out of the central blanket area. Set it to one side and release mechanism.

17. With the cup locked in the desired angular position, bring the bridge north and a track stop will position it. Run the trolley west, and the track stop will center the manipulator over a blanket brick.

18. Lower the manipulator so the dowel engages the 2-inch control rod hole in the blanket brick. Close the grip when the angular rotation of the manipulator is correct and lift the brick out.

19. Rotate the cup and repeat Step 18 until the desired number of bricks are removed.

20. A record must be kept of the cup position of each brick and its storage location.

21. Assemble the cup in the reverse order.

22. Place the aluminum liner in the center.

23. Place the aluminum sleeve around the outside.

24. When the ram is in its original angular rotation, raise it.

25. Engage the horse shoe carrier.

26. Lower the ram

27. Run the carrier into the elevator room.

28. Change the upper controls and run carrier to stops.

29. Raise elevator and back carrier into repair room.

30. Change to lower control panel and close lead shielding door.

31. De-energize and lock control panel.

APPENDIX "A"

INTERLOCKS

Immediate Scram Interlocks

	Function	Normal	Scram
1.	Period A Negative	15 sec	15 sec
2.	Period A Positive Adjustable	15 to 75 sec	Below set point
3.	Period B Negative	5 sec	5 sec
4.	Period B Positive	5 sec	5 sec
5.	Reactor Coolant Flow	290 gpm	Below 200 gpm for power operation. May be lowered for low power operation.
6.	Reactor Inlet Temperature	228° C	Above 300° C
7.	Reactor Outlet Temperature	316° C	Above 375° C
8.	Exchanger Outlet Temperature	228° C	Above 375° C
9.	Fuel Temperature	392° C	Above 500° C
10.	Blanket Rod Temperature	320° C	Above 500° C
11.	Elevator Jack Contact	On Jacks	Off Jacks
12.	Gravity Tank Outlet Valve	Open	Closed
13.	Gravity Tank Drain Valve	Closed	Open
14.	Reactor Overflow Valve	Open	Closed
15.	Receiving Tank Overflow Valve	Open	Closed
16.	Flux Level No. 1		20% above normal current

Immediate Scram Interlocks (Cont'd.)

	Function	Normal	Scram
17.	Flux Level No. 2		20% above normal current
18.	Reactor Assembly Internal Valving a. Inlet Valves b. Throttle Valves	Valves in correct position for series or parallel flow	Valves not in correct position for series or parallel flow

Delayed Scram Interlocks (2-minute delay)

	Function	Normal	Scram
1.	Pumped Coolant Flow	345 gpm	Below 250 gpm
2.	Circulating Gas Flow	10 cfm	Below 1 cfm
3.	Compressed Air Supply to Valve Operators	120 psig	Below 75 psig
4.	Elevator Hydraulic Pressure	950 to 1180 psig	Below 900 psig
5.	Automatic Control	Adjustable	5 cm beyond control point
6.	Cup Air Flow	5800 cfm	Below 4500 cfm

Alarm Interlocks

	Function	Normal	Scram
1.	Secondary Coolant Flow	280 gpm	250 gpm
2.	Gas Pressure Pump No. 1	3.0 psi	Below 1.5 psi
3.	Primary Blanket Gas Pressure	3.0 psi	Below 1.5 psi
4.	Secondary Blanket Gas Pressure	5.0 psi	Below 3.0 psi
5.	Gas Pressure Secondary Pump	5.0 psi	3.0 psi
6.	Pump No. 1 Underspeed	1760 rpm	1600 rpm
7.	Expansion Tank Level	Above 10 inches	Below 6 inches

Alarm Interlocks (Cont'd.)

	Function	Normal	Scram
8.	Secondary Receiver Tank Level	Above 13 inches	Below 13 inches
9.	Reactor Overflow	No overflow	Overflow
10.	Pump No. 1 High Level		High Level
11.	Electromagnetic Pump Probe		NaK in pump case
12.	Secondary Pump High Level		High Level
13.	Gas Trap High Level	NaK below probe	NaK above probe
14.	Liquid Heater Over-Temperature		Above 350° C
15.	Boiler Pump Cooling Water	On	Off
16.	Blanket Gas Supply Pressure	60 psi	52 psi
17.	Exhauster Cooling Water	On	Off
18.	Gravity Tank Level	108 inches	Below 96 inches
19.	Pump Temperature	25 to 60° C	Above 80° C
20.	Secondary Pump Underspeed	1760 rpm	Below 1600 rpm
21.	Smoke Detector		Smoke in cells
22.	Smoke Detector Trouble		Detector not operating
23.	Transfer Pump Probe		NaK in pump case

APPENDIX "B"

REACTOR STARTUP CHECK SHEET

Date ________________________________ Page __________

Time ________________________________ Operator ____________________

1. Flow distribution inlet valve position-reactor flow series or parallel . . . . ________
2. Blanket flow throttling valve--closed in series flow; throttled in parallel flow - amount open ______________; locked in position . . . . ________
3. Primary coolant flow . . . . ________gpm
4. Primary coolant flow alarm setting . . . . ________gpm
5. Convector inlet and expansion tank blanket gas valves closed . . . . ________
6. Air line to expansion tank blanket gas valve operator open . . . . ________
7. Primary coolant temperature recorders operating . . . . . . ________
8. Pumped coolant flow . . . . ________gpm
9. Pumped coolant flow alarm setting . . . . ________gpm
10. Fuel temperature recorder operating . . . . ________
11. Blanket rod temperature recorder operating . . . . ________
12. Primary gravity tank full . . . . ________
13. Primary receiving tank above 22 inches . . . . ________
14. Secondary coolant flow . . . . ________gpm
15. Circulating gas flow rate . . . . ________cfm
16. Circulating gas flow alarm setting . . . . ________

Page ________________ Date ____________________________

17. Circulating gas temperature recorder operating . . . . ________

18. Reactor supply air flow . . . . ________cfm

19. Upper blanket exhaust . . . . ________cfm

20. Reactor cup exhaust . . . . ________cfm

21. Electrostatic filter on . . . . ________

22. Cell ventilation on . . . . ________

23. Building ventilation on . . . . ________

24. Cup air temperature recorder operating . . . . ________

25. Elevator operative . . . . ________

26. Jacks operative . . . . ________

27. Control rods operative . . . . ________

28. Safety rods operative . . . . ________

29. Block operative . . . . ________

30. Galvanometers zeroed . . . . ________

31. Power level shunt position . . . . ________

32. Differential power shunt position . . . . ________

33. Wet cell voltage . . . . ________

34. Power chamber voltage . . . . ________

35. Differential chamber voltage . . . . ________

36. Chamber supply voltages . . . . ________

37. Safety # ________________ Trip Setting . . . . ________

38. Safety # ________________ Trip Setting . . . . ________

Page ____________________ Date ____________________

39. Period A trip setting . . . . ____________

40. Period B trip setting . . . . ____________

41. Vibrating reed operative . . . . ____________

42. Vibrating reed scale and resistance . . . . ____________

43. Counter operative . . . . ____________

44. Counter scale . . . . ____________

45. Estimated critical position:

Control Rod #1 . . . . ________ Control Rod #2. . . ____________

Control Rod #3 . . . . ________ Control Rod #4. . . ____________

Jacks . . . . ________ Temperature . . . . ____________

46. Previous Startup:

Temperature . . . . ____________

Jacks . . . . ____________

Period . . . . ____________

APPENDIX "C"

INTERLOCK CHECK ON ________, 195__

Reactor Section

1. Will safety rods go up with block down? ____________________
2. Does tripping block trip safety rods? ____________________
3. Will elevator go above 30 inches with safeties down? __________
4. Will tripping one safety rod stop elevator if above 30 inches? ____________________
5. Will elevator go up with jacks above lower limit? __________
6. Will moving jacks off lower limit stop elevator if above 30 inches? ____________________
7. Do jacks come down on "Reactor Shut Down" trip? __________
8. Do jacks come down on "Reactor Off" trip? __________
9. Setting on Safety Circuit# ____ - Range ____ Trip Setting ____
10. Setting on Safety Circuit# ____ - Range ____ Trip Setting ____
11. Trip level on # ___ ________ kw. Previous trip level ________ kw
12. Trip level on # ___ ________ kw. Previous trip level ________ kw
13. Trip level settings after testing # ______ Range _____ Trip Setting _____
    # ______ Range _____ Trip Setting _____
14. Period to trip Period Meter A: On Period Meter __________ sec on Vibrating Reed ________ sec
15. Did Period Meter B trip on negative period at scram? __________
16. Period to trip Period Meter B: On Period Meter __________ sec electronic trip check.
17. Did Period Meter A trip on negative period at scram? __________

Reactor Section (Cont'd.)

18. Previous trip levels: A ______ , ______; B ______ , ______

19. Trip level settings after testing: A ______ , B ______

20. Time to scram when automatic control goes above top power limit ______ min

21. Time to scram when automatic control goes below power limit ______ min

22. Low hydraulic pressure trips interlock at ______ psi

23. Does reactor scram when elevator comes off top limit ? ______

*24. Low compressed air supply interlock trips at ______ psi

Coolant Section

1. Reactor internal valve position interlock

   (a) Series flow: Does opening blanket flow throttling valve scram reactor ? ______

   (b) Parallel flow: Does closing blanket flow throttling valve scram reactor? ______ Note: Interlock shall be checked for either series or parallel flow position as indicated.

2. Blanket flow throttling valve locked in position ______

3. Does pumped coolant flow alarm sound when flow falls below setting ? ______

4. Normal setting of this interlock ______ gpm

5. Does reactor coolant flow dropping below interlock setting scram reactor ? ______

6. Does reactor flow dropping below interlock setting open convection loop ? ______

7. Normal setting of this interlock ______ gpm

*Items so marked may be checked only on first interlock check of each month if Chief Operator so desires.

Coolant Section (Cont'd.)

8. Does power failure open convection loop? ____________________

9. Over-temperature of reactor inlet trips at ____________________ °C

10. Over-temperature of reactor outlet trips at ____________________ °C

11. Over-temperature of heat exchanger outlet trips at ____________________ °C

12. Over-temperature of fuel trips at ____________________ °C

12a. Over-temperature of blanket rod trips at ____________________ °C

*13. Reactor overflow trips at ______ gpm at ____________________ °C

14. Previous overflow trip ________ gpm at ____________________ °C

15. Does closing gravity tank outlet valve cause scram? ____________

*16. Does opening gravity tank drain valve cause scram? ____________

17. Does closing reactor overflow valve cause scram? ____________

18. Does closing receiver tank overflow valve cause scram? ________

19. Does closing receiver tank overflow or reactor overflow valve also cause gravity tank shut-off valve to close? ____________

*20. Does low level in gravity tank sound alarm? ____________________

21. Does secondary cooling flow dropping below interlock setting sound horn? ____________________

22. Normal setting of this interlock ____________________ gpm

23. Does mechanical primary pump under-speed sound horn? ________

24. Does secondary pump under-speed sound horn? ____________

25. Do primary or secondary mechanical pump high temperatures sound horn? ____________________

---

*Items so marked may be checked only on first interlock check of each month if Chief Operator so desires.

Coolant Section (Cont.d.)

26. Does circulating gas flow falling below interlock setting cause delayed scram? __________

*27. Low gas pressure in the primary system sounds horn at __________ psi

*28. Low gas pressure in the secondary system sounds horn at __________ psi

*29. Low gas pressure in the supply system sounds horn at __________ psi

30. Do high levels in pumps sound horn? _____ #1 _____ , Secondary _____

31. Does gas trap high level alarm sound horn? __________

32. Does loss of boiler pump cooling water sound horn? __________

33. Does loss of cooling water cup exhauster sound horn? __________

34. Does loss of cup cooling air cause delayed scram? __________

35. Can reactor supply air be turned on before both graphite and cup exhauster are on? __________

36. Does shorting probe lead in primary EM pump sound horn? __________

37. Does smoke detector trip on smoke from cold pump room? __________

38. Does smoke detector trip sound horn? __________

General

1. List all malfunctions by letter and number above __________
2. Have these been corrected? __________
3. Have interlock panels been visually inspected for blocked relays, burned out coils, etc.? __________
4. Have all padlocks been replaced and locked? __________

This interlock check made by: Approved by:

1. ____________________ ____________________

Shift supervisor Division Director

2. ____________________

3. ____________________

4. ____________________

*Items so marked may be checked only on first interlock check of each month if Chief Operator so desires.

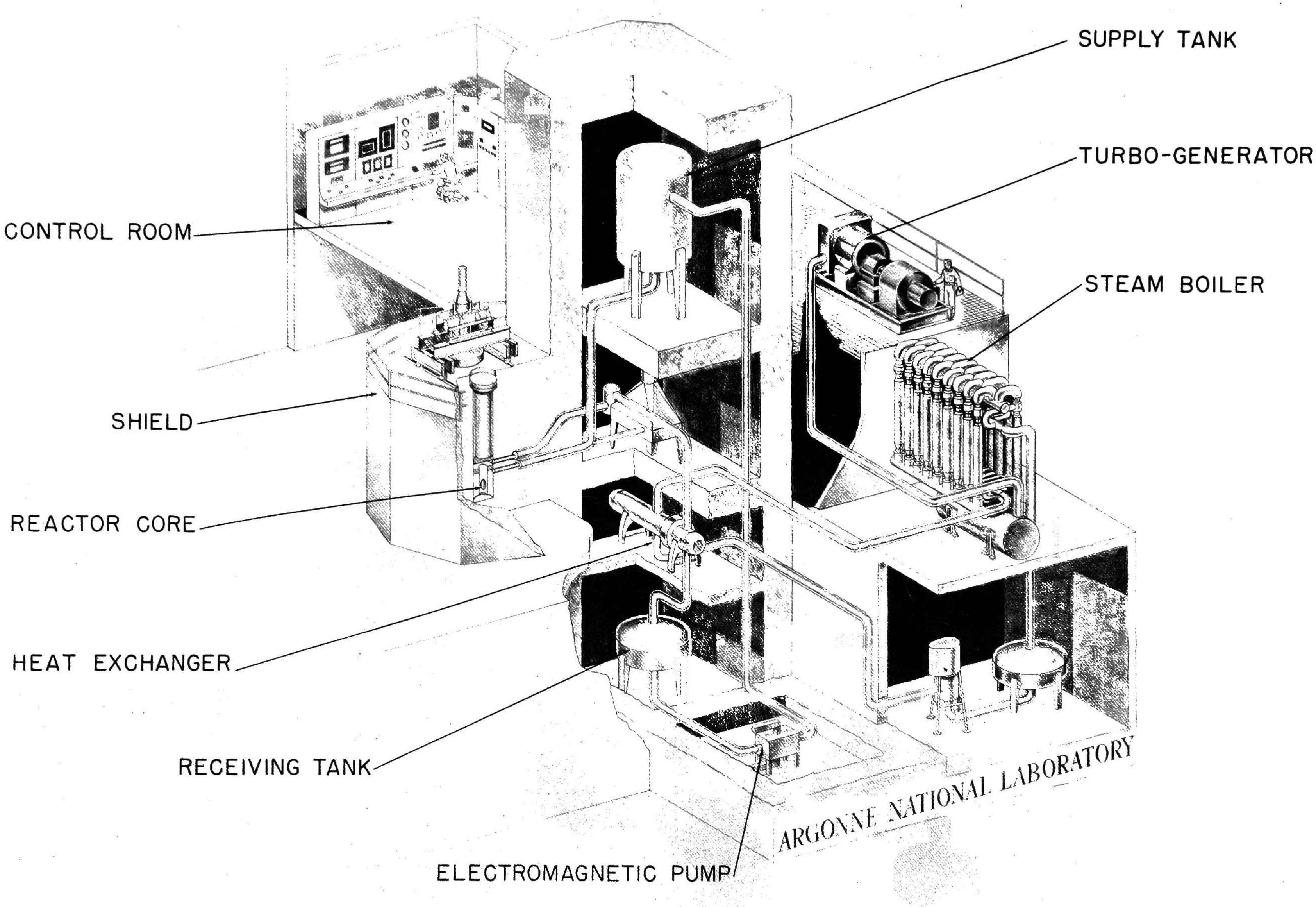

FIG. 1. REACTOR SYSTEM - EBR-I

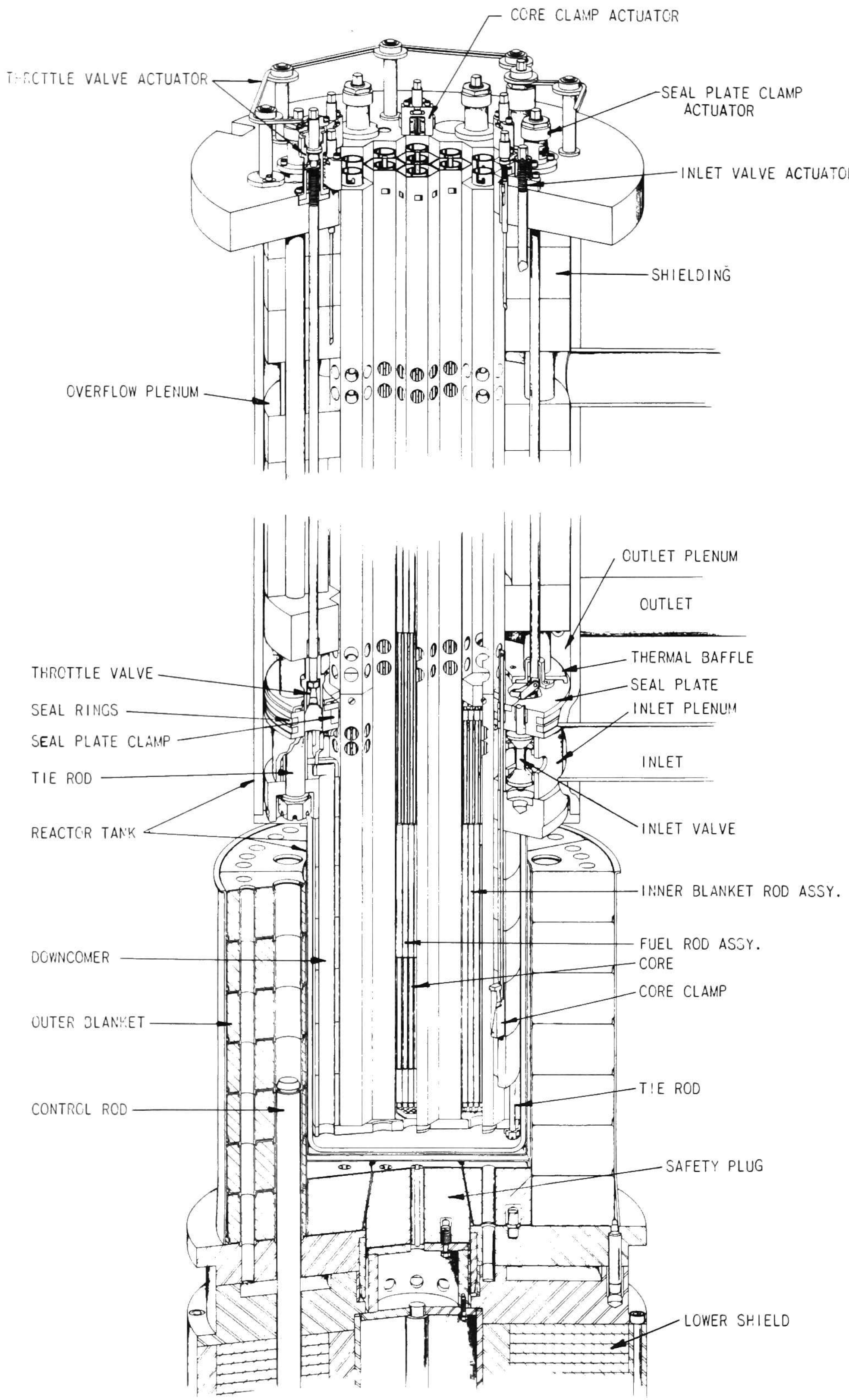

FIG. 2
INNER TANK ASSEMBLY EBR I, MARK III

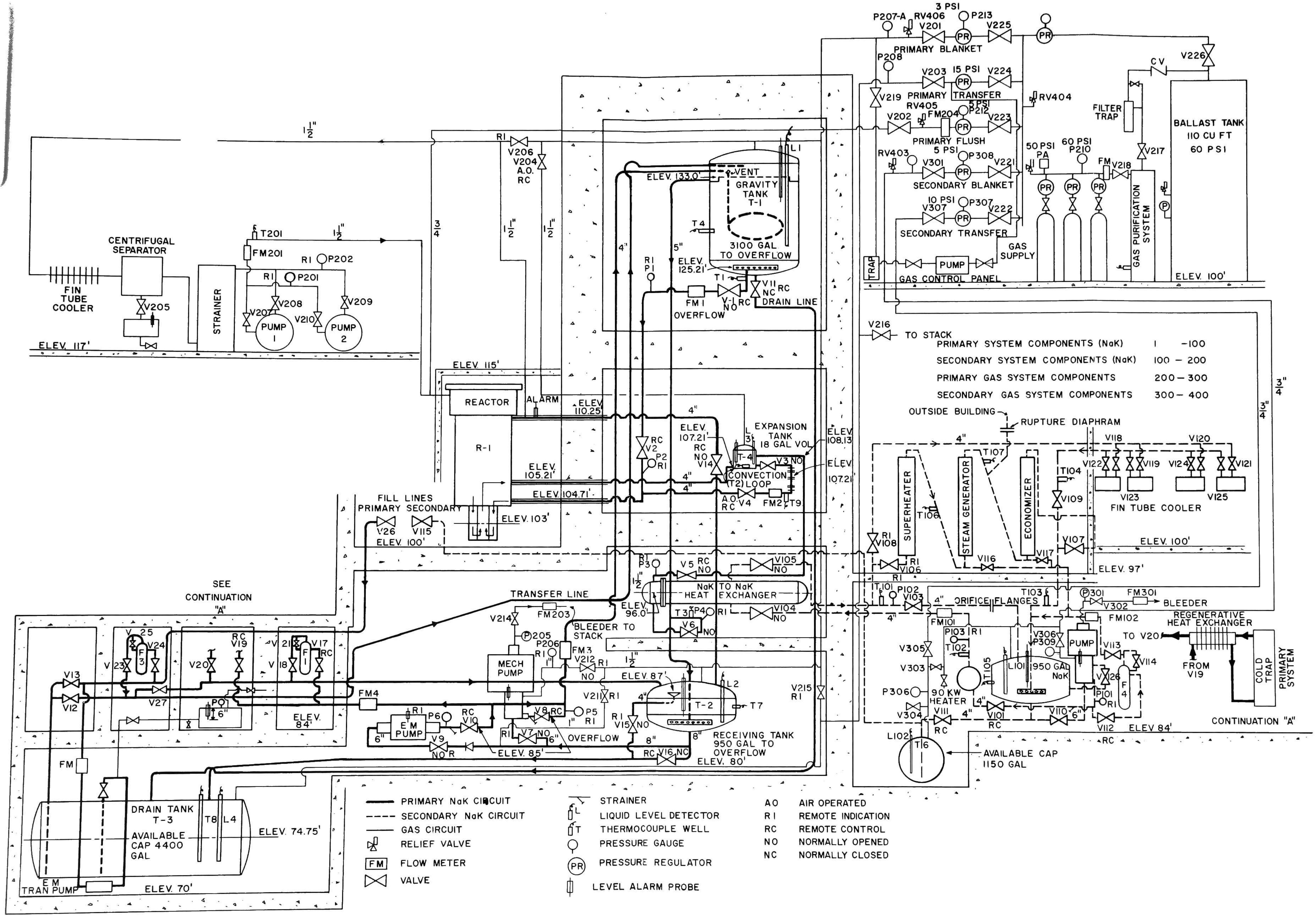

FIG. 3

NaK SYSTEMS E.B.R.-I

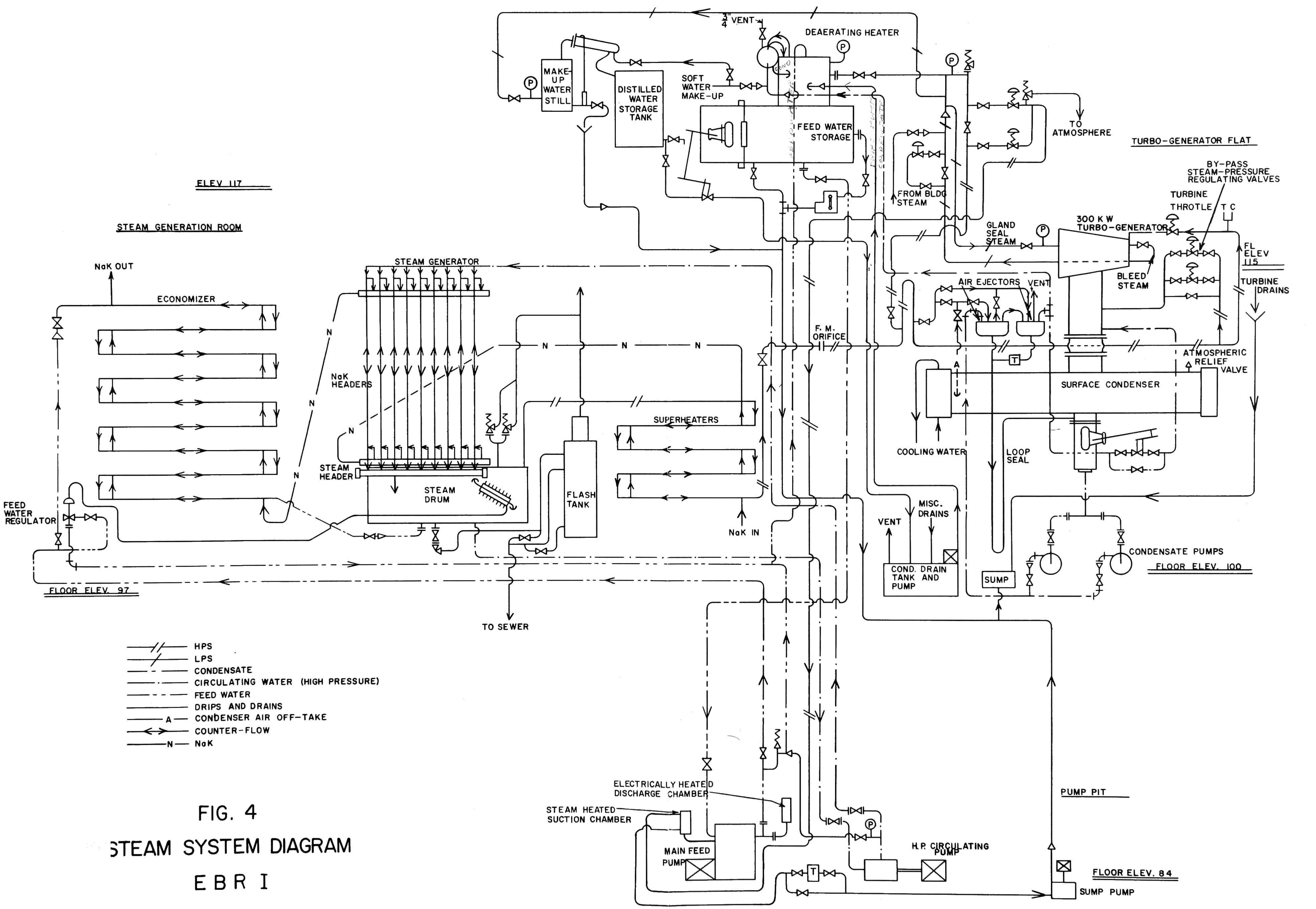

FIG. 4

STEAM SYSTEM DIAGRAM

E B R I

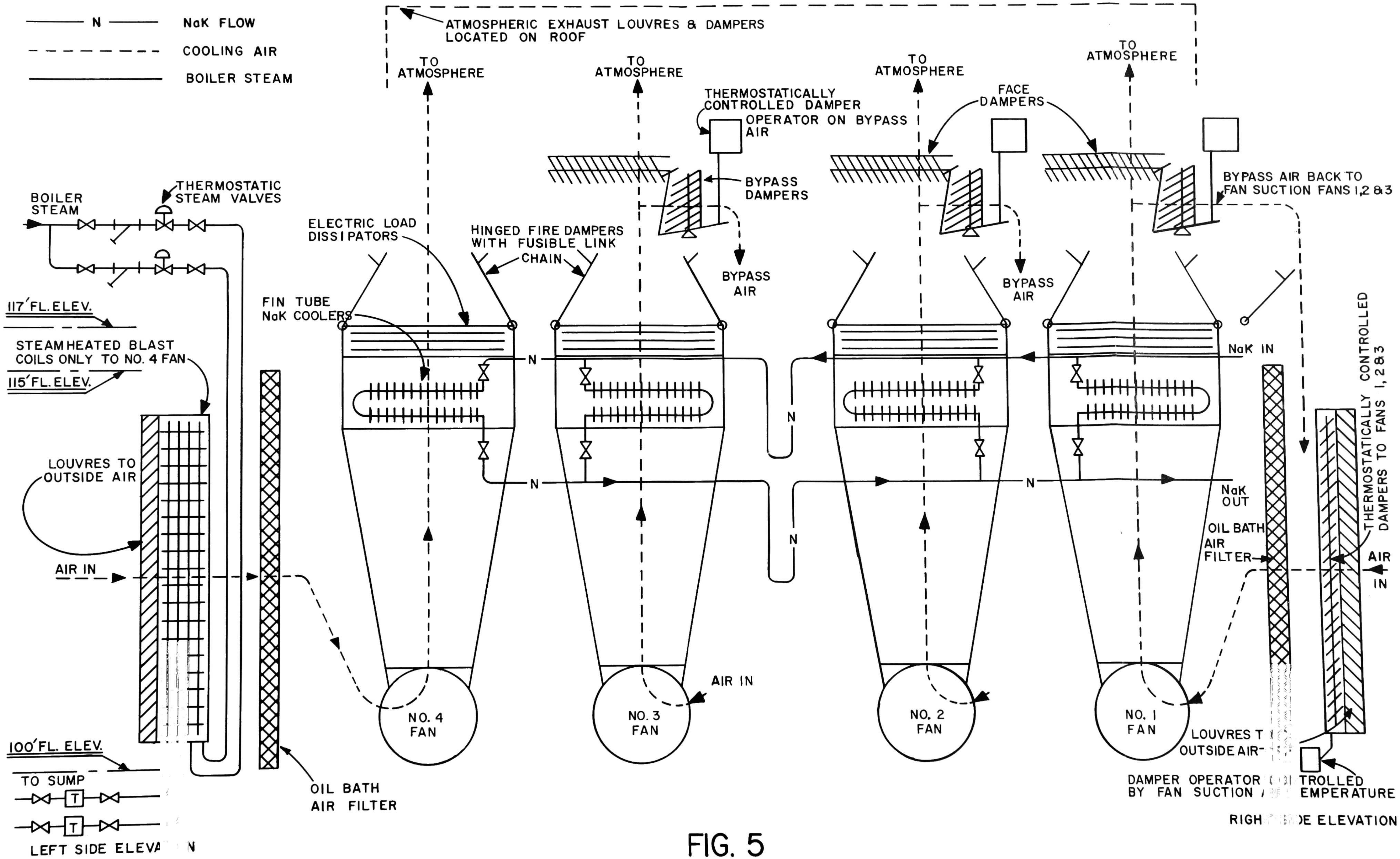

FIG. 5

E.B.R. LOAD DISSIPATOR AND NaK-AIR HEAT EX.

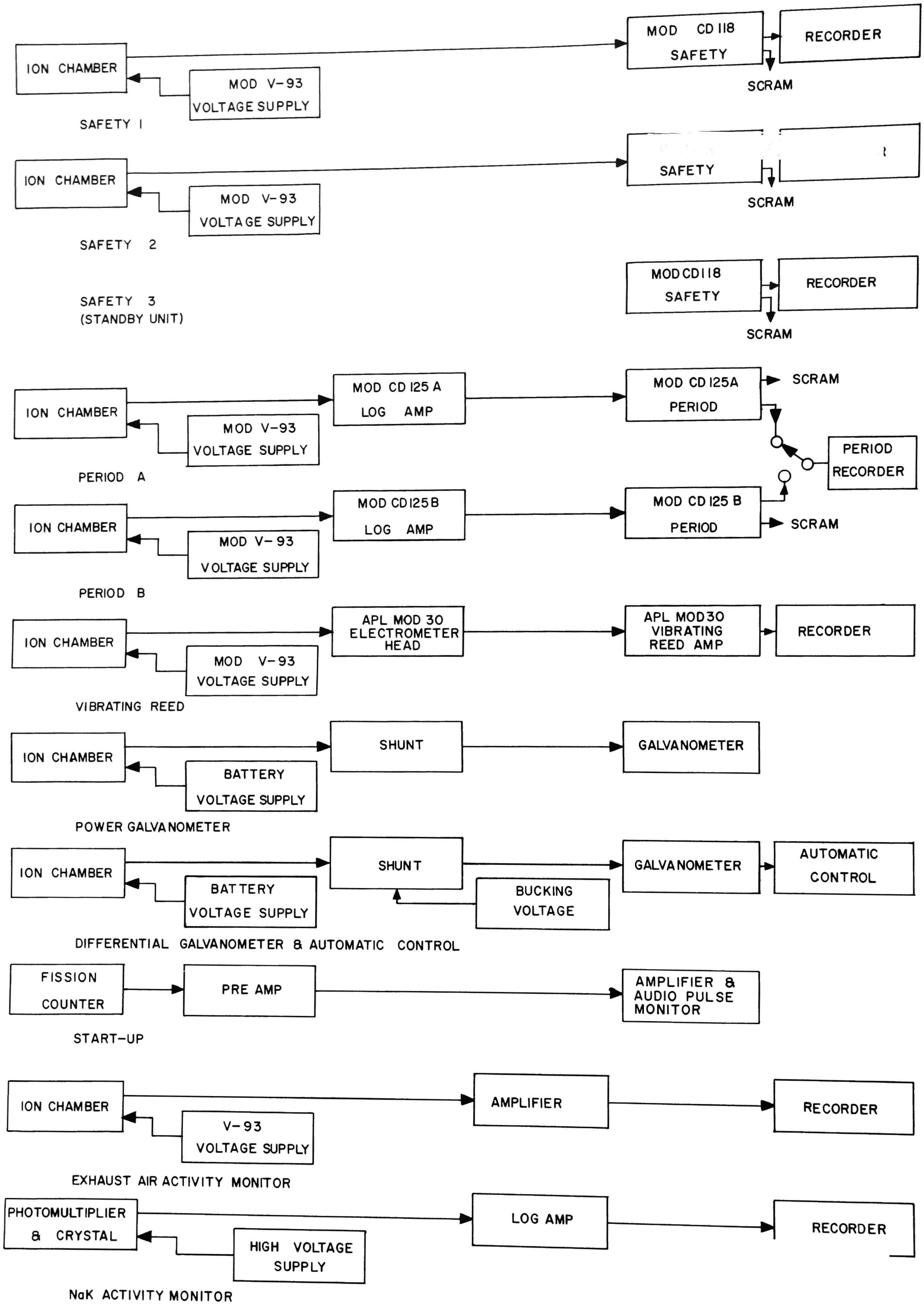

FIG. 6 EBRI MK III, NUCLEAR INSTRUMENTATION

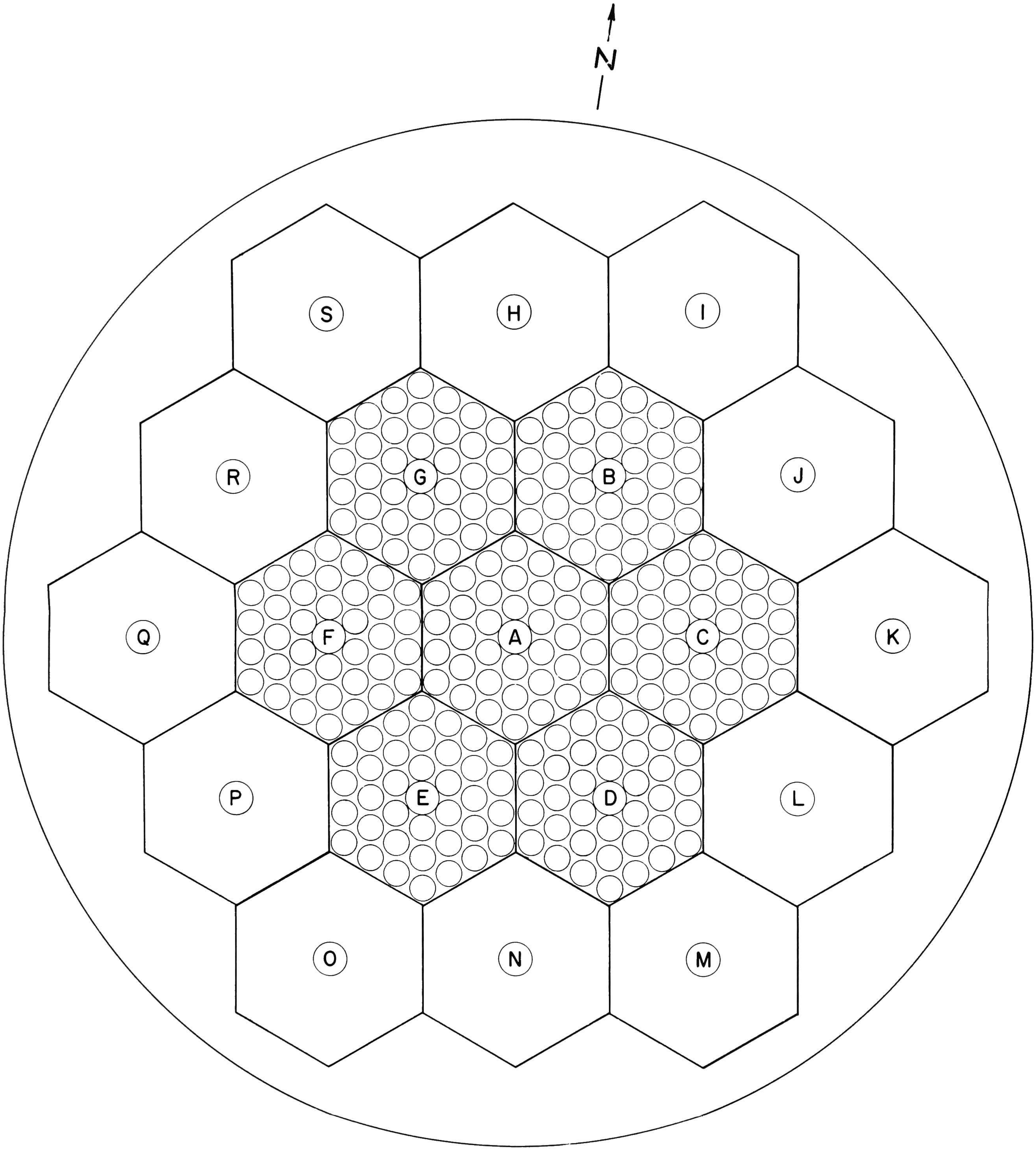

FIG. 7
LOADING DIAGRAM
E.B.R. I, MARK III

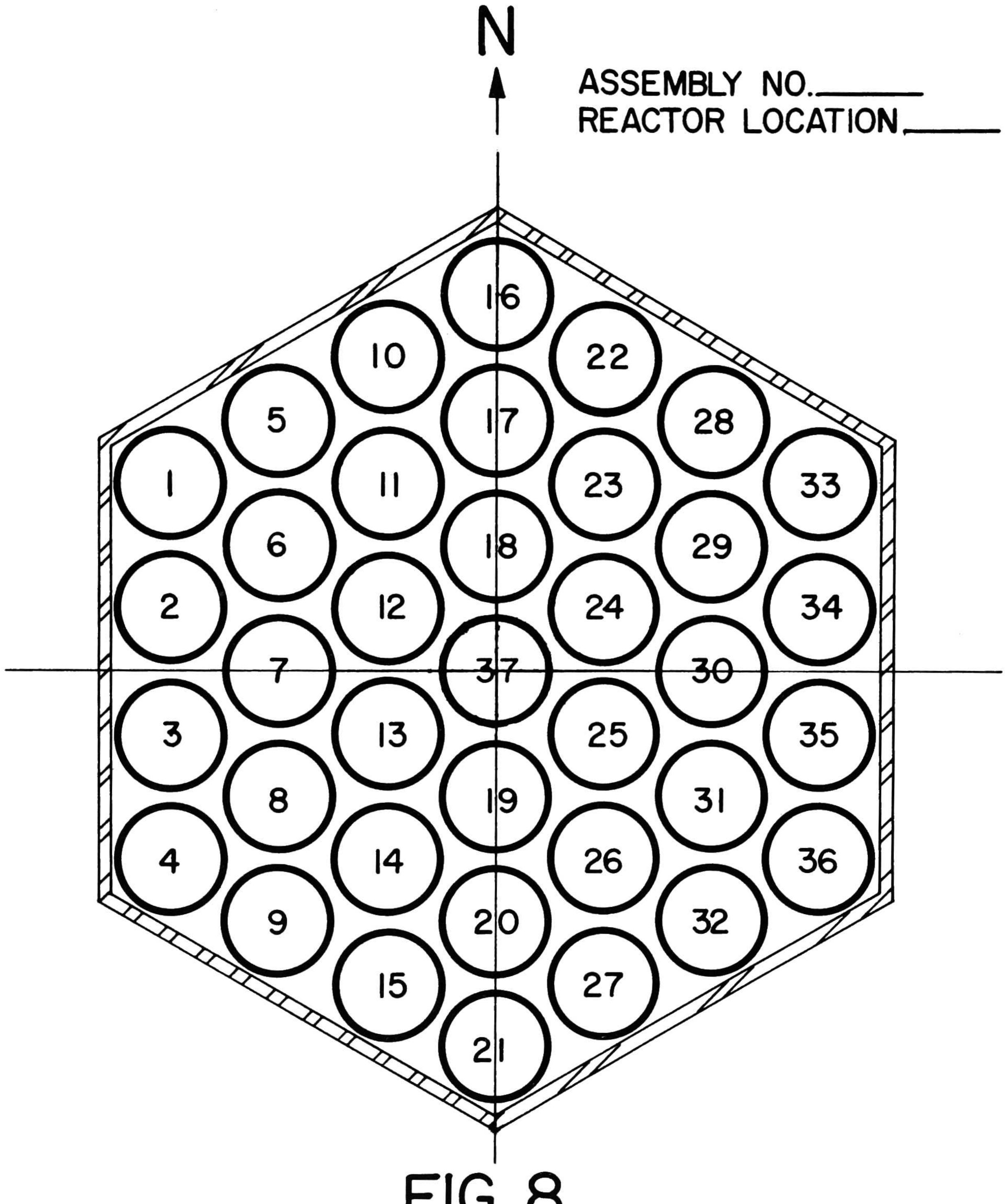

FIG. 8
SUB-ASSEMBLY
LOADING DIAGRAM

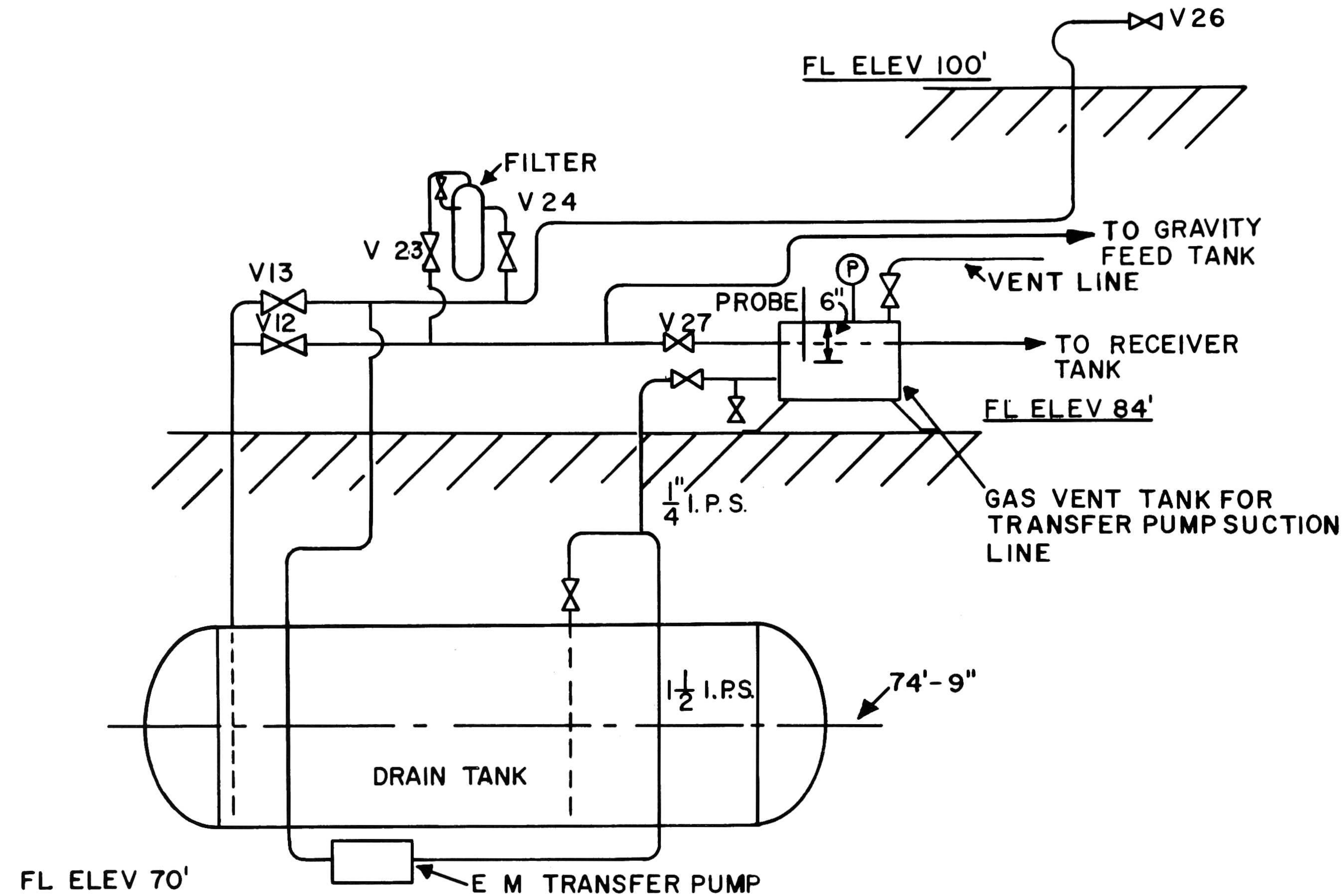

FIG. 9
E.M. NaK TRANS. AND FILL SYSTEM

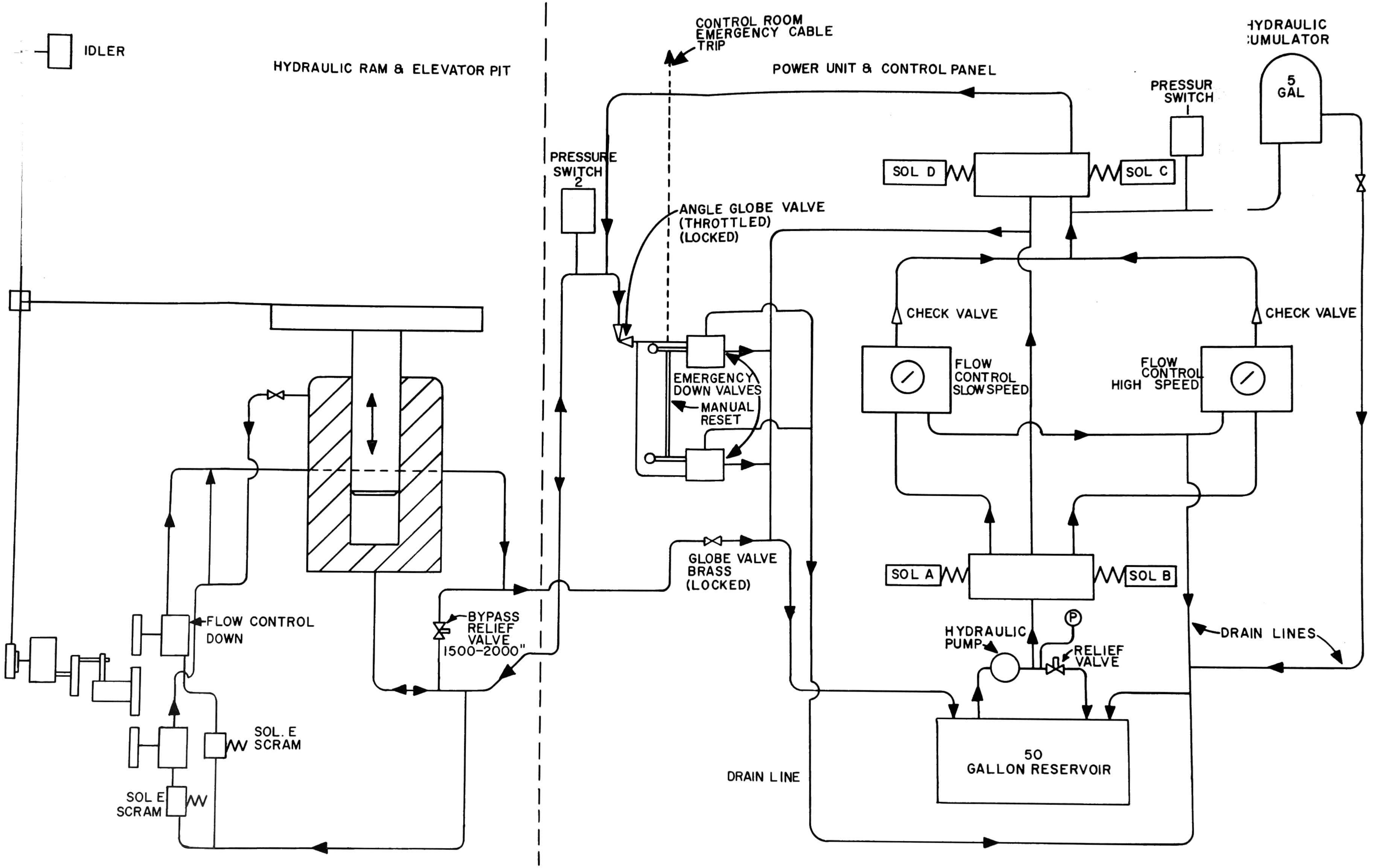

FIG. 10
REACTOR HYDRAULIC SYSTEM

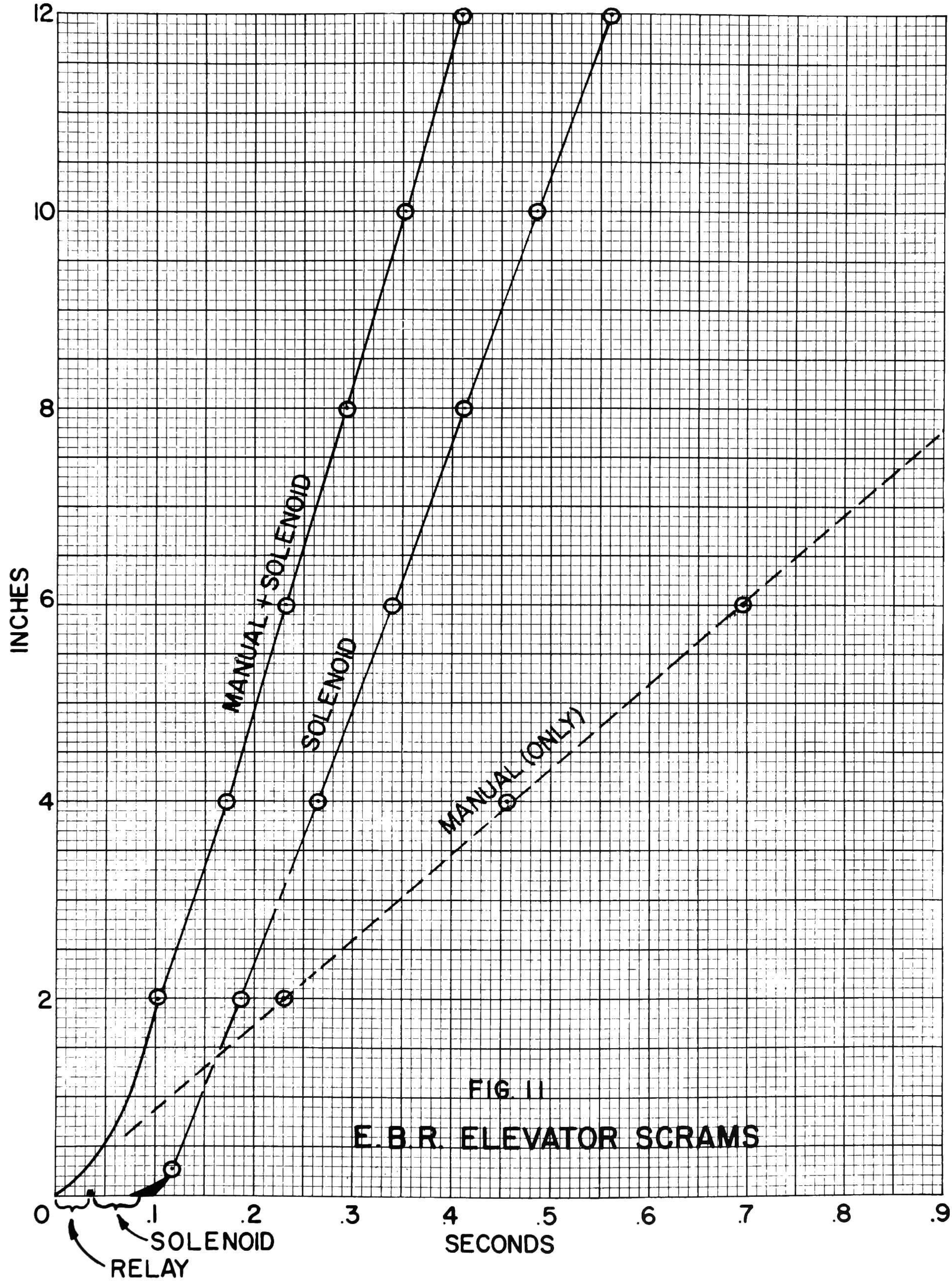

FIG. 11

E.B.R. ELEVATOR SCRAMS

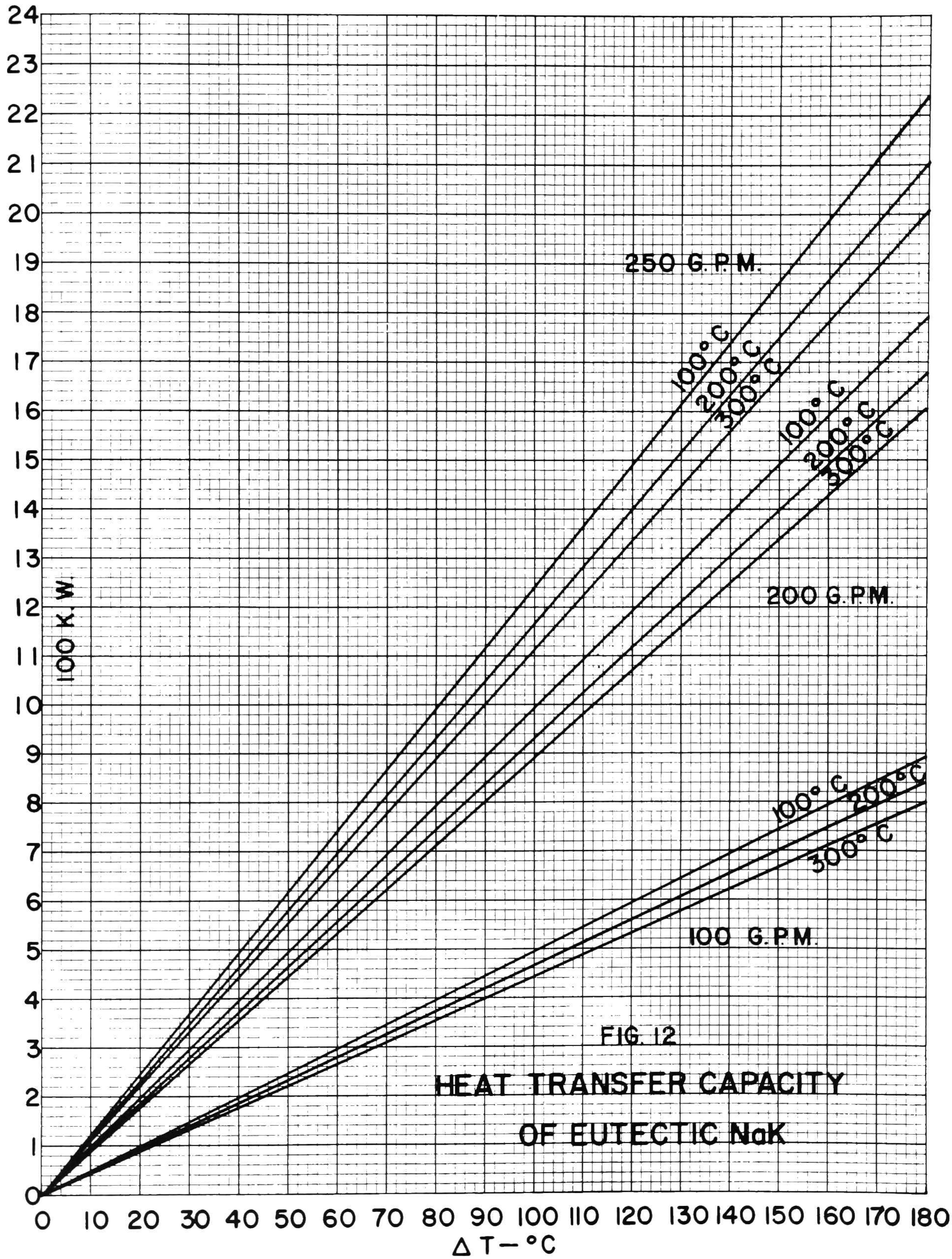

FIG. 12

HEAT TRANSFER CAPACITY

OF EUTECTIC NaK

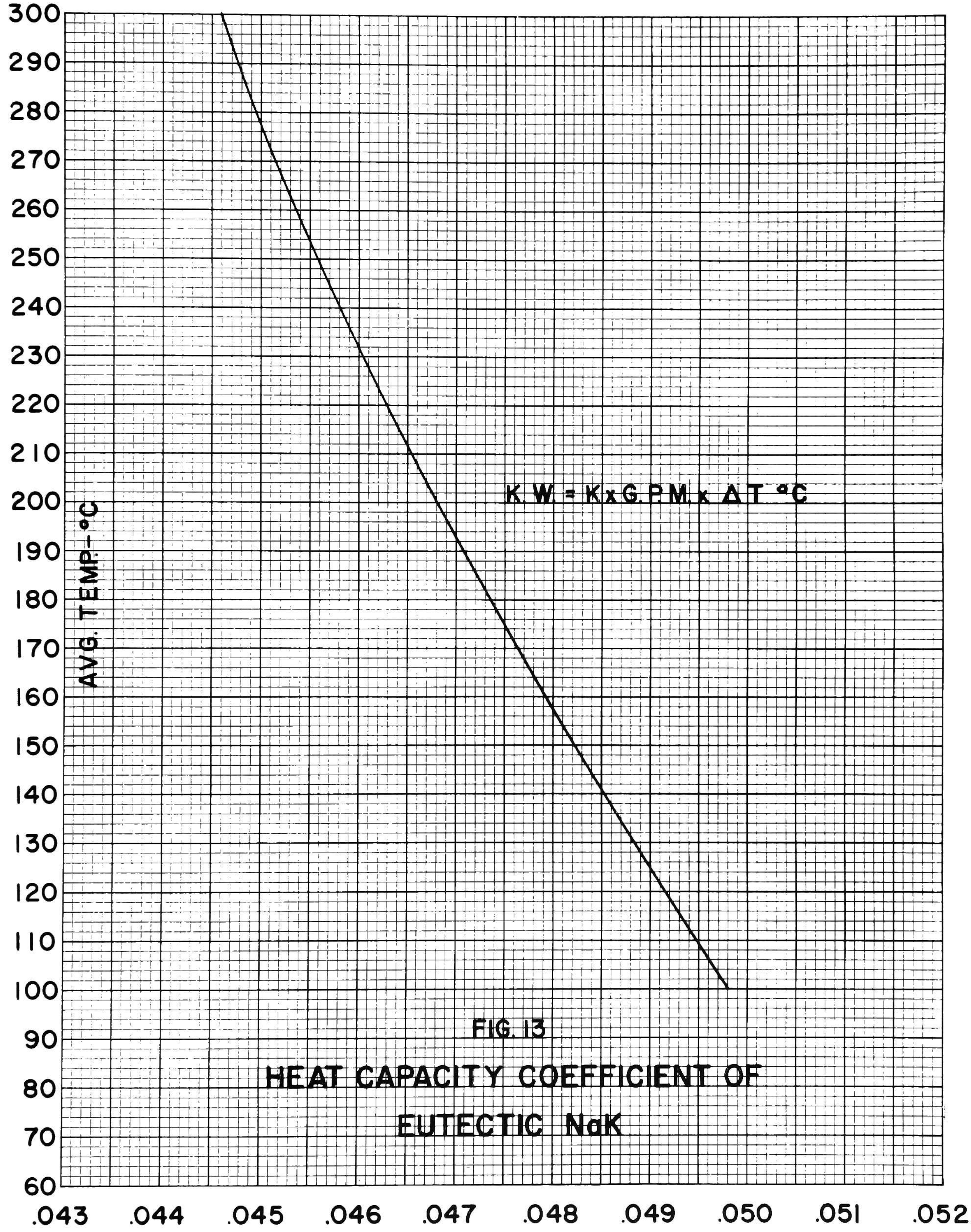

FIG. 13

HEAT CAPACITY COEFFICIENT OF EUTECTIC NaK

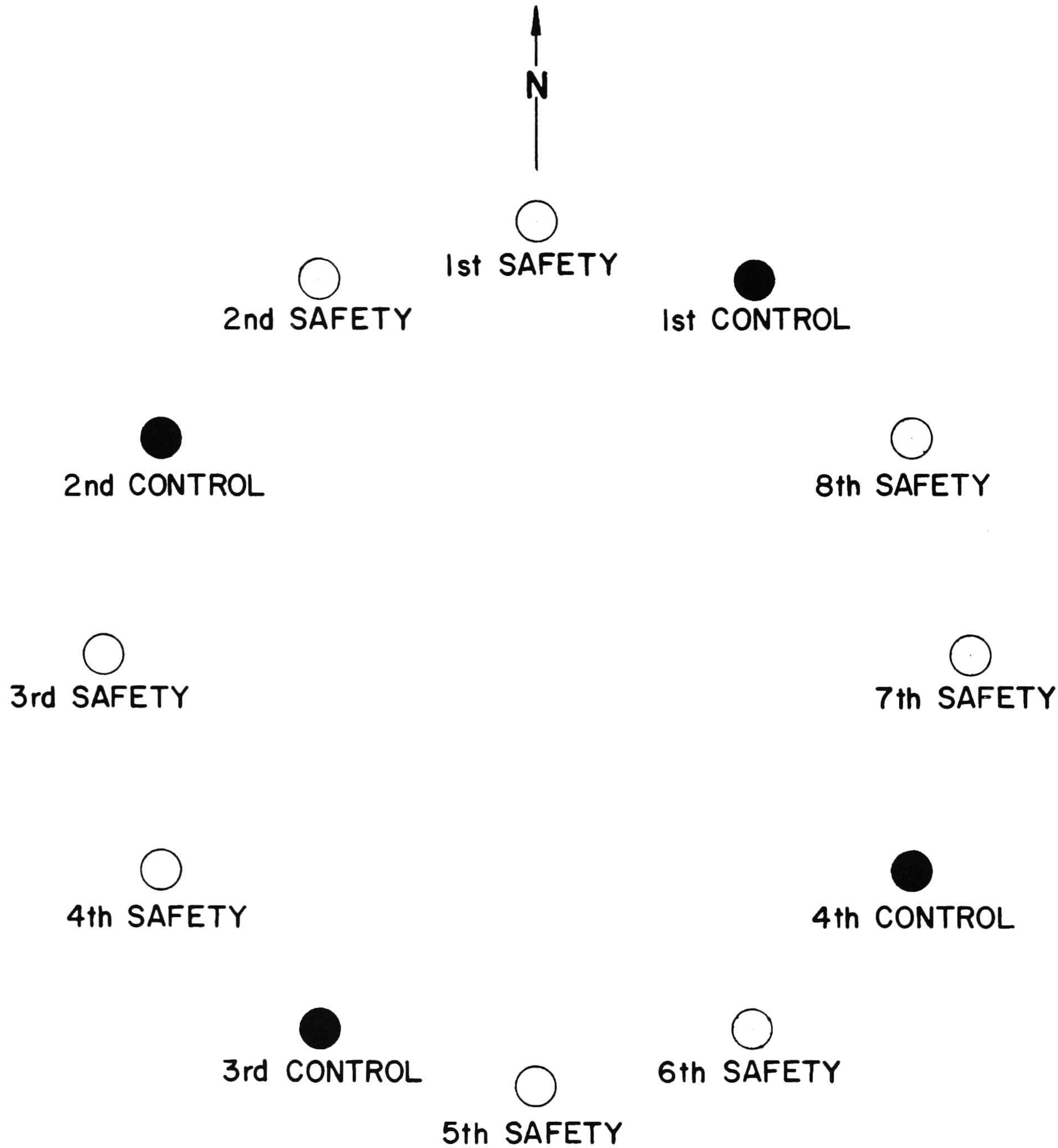

FIG. 14
SAFETY ROD & CONTROL ROD LOCATIONS

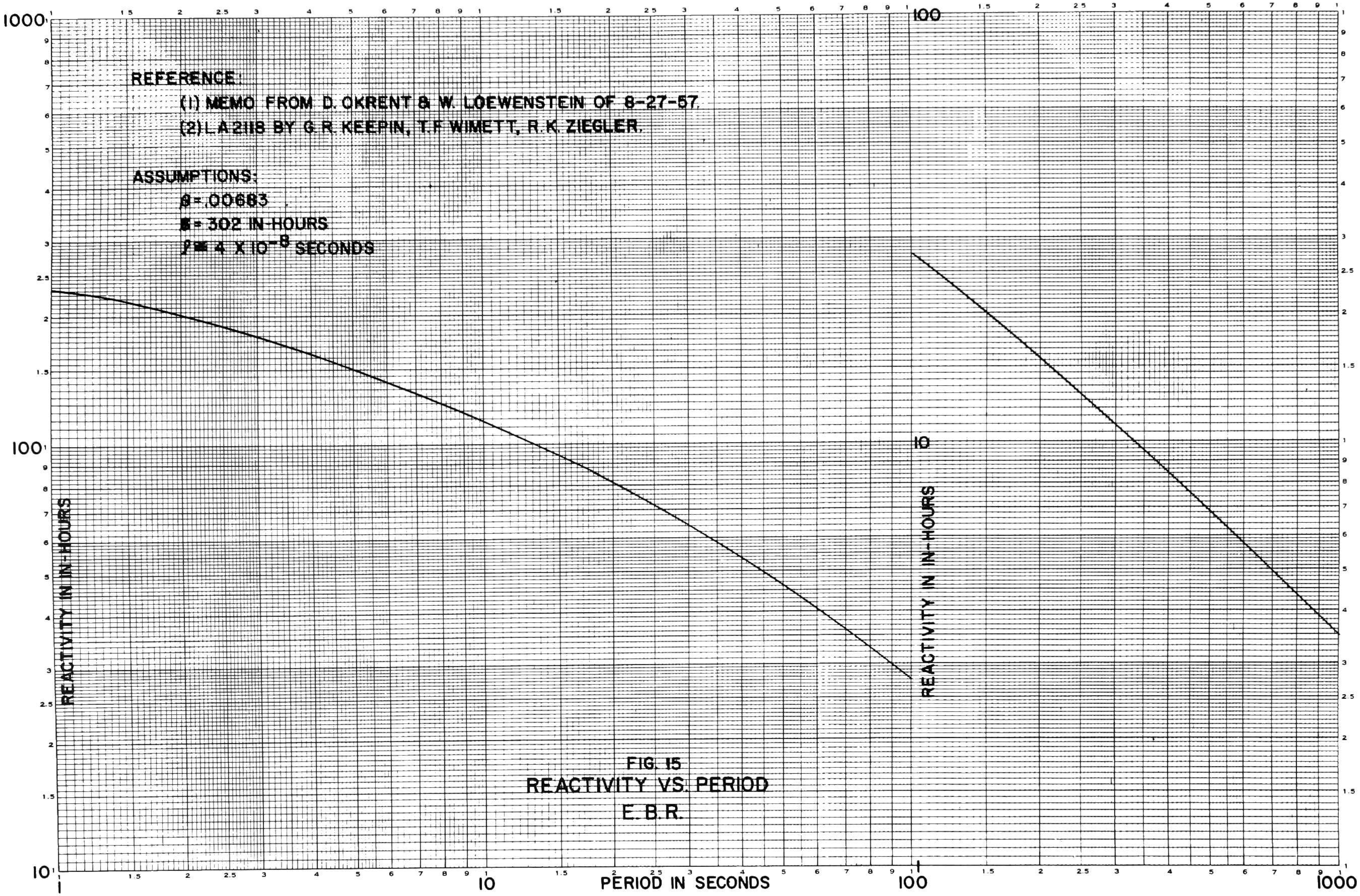

FIG. 15
REACTIVITY VS. PERIOD
E. B. R.

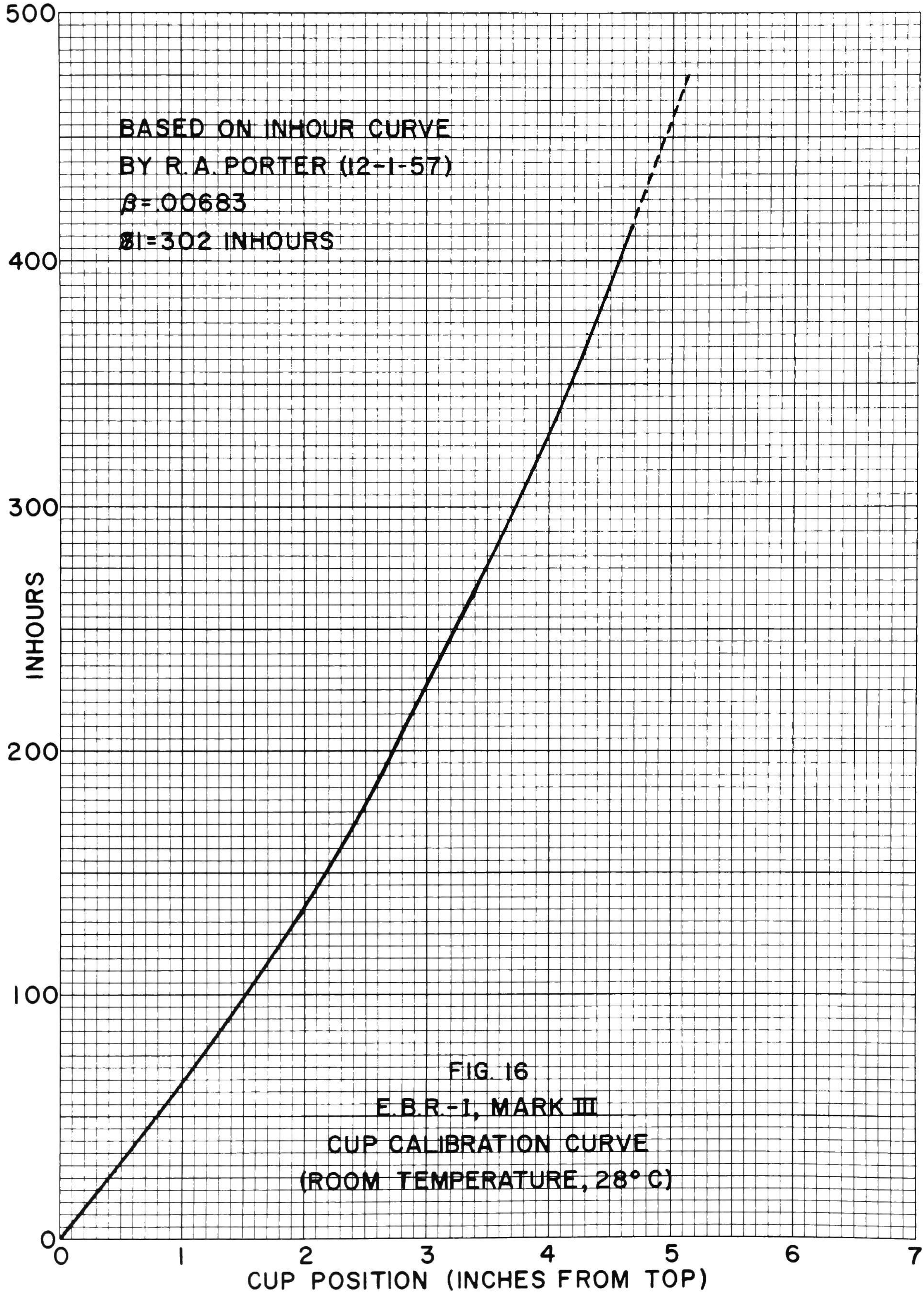

FIG. 16
E.B.R.-I, MARK III
CUP CALIBRATION CURVE
(ROOM TEMPERATURE, 28° C)

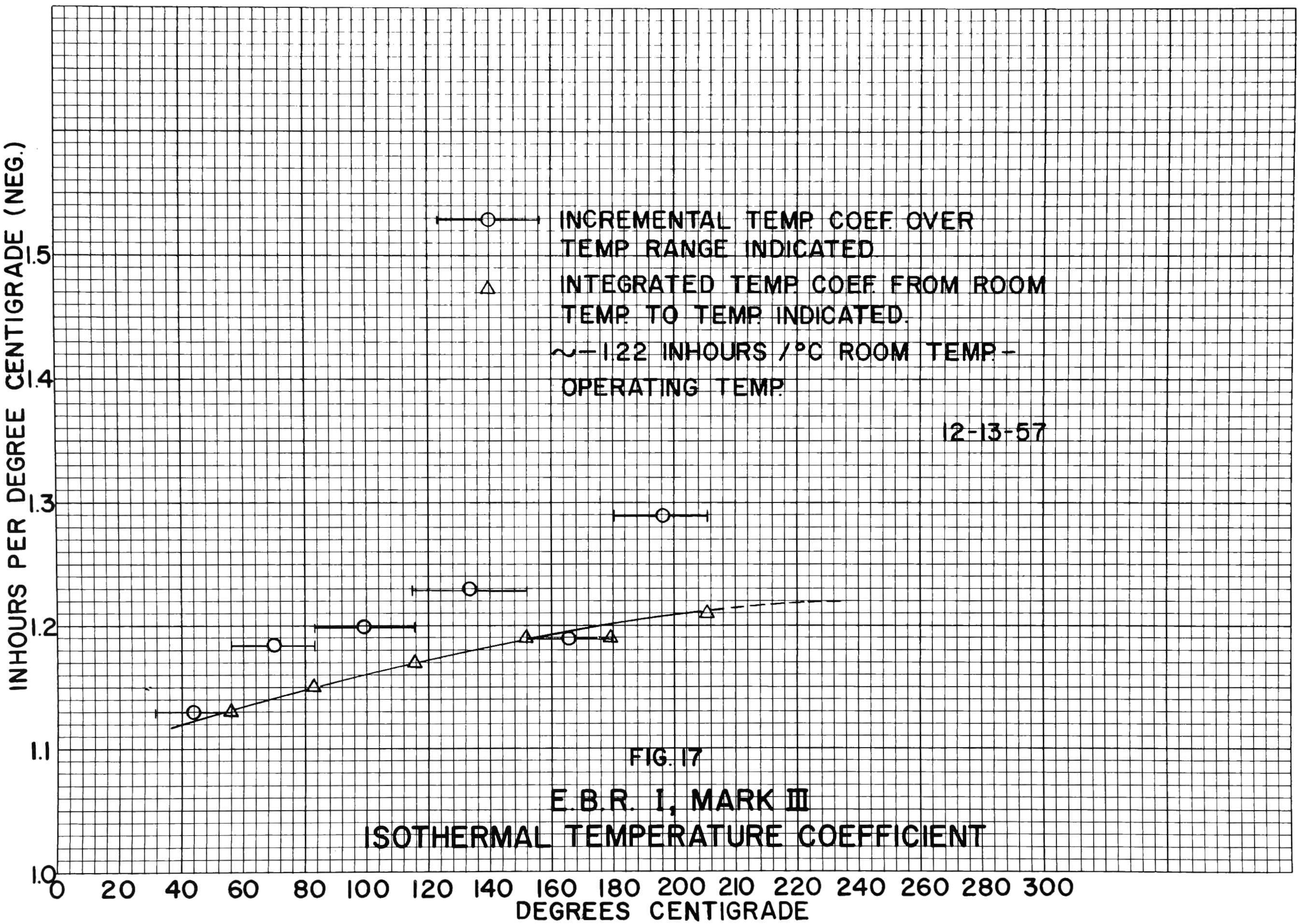

FIG. 17

E.B.R. I, MARK III

ISOTHERMAL TEMPERATURE COEFFICIENT

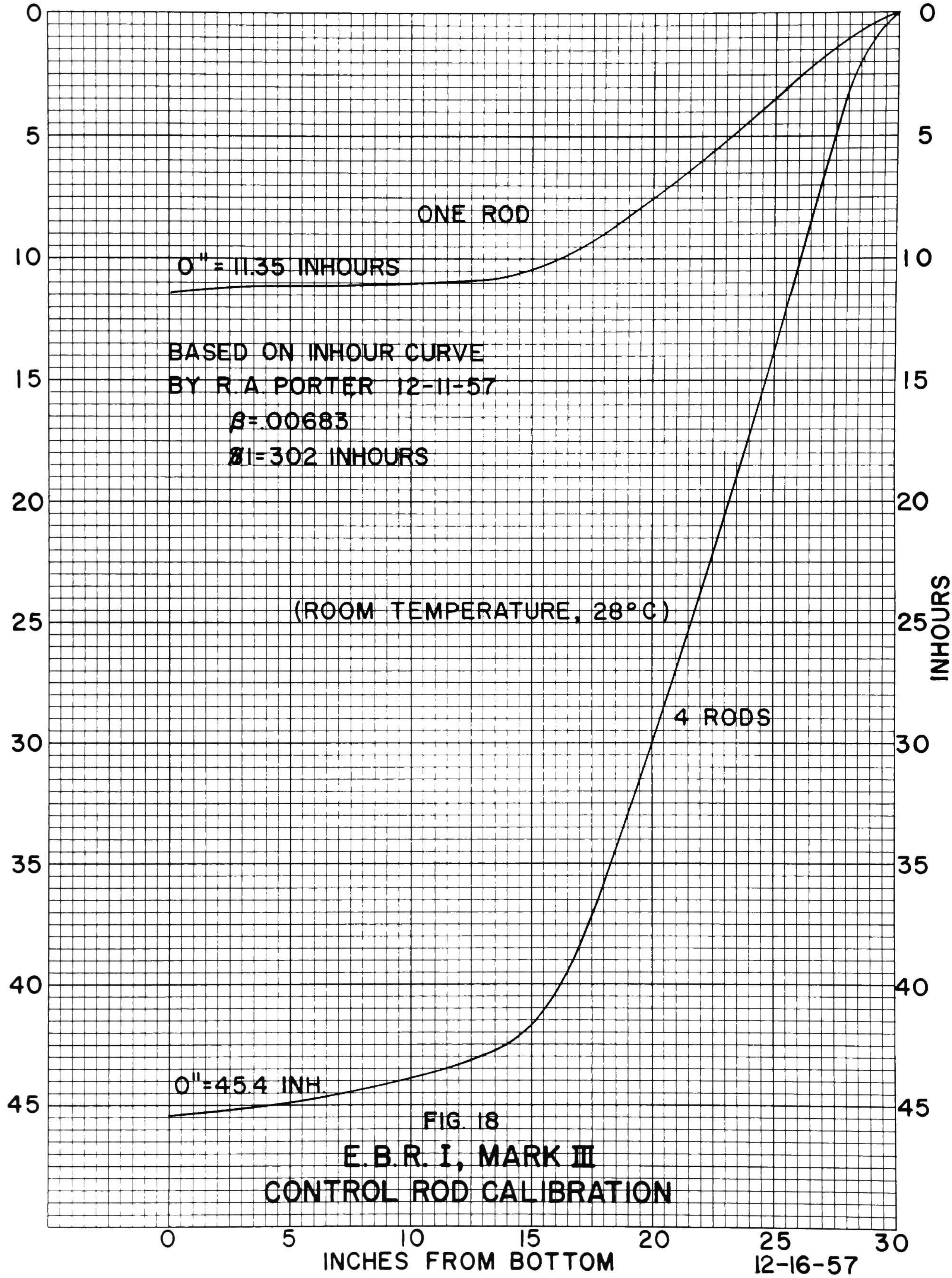

FIG. 18

E.B.R. I, MARK III
CONTROL ROD CALIBRATION